However, the panelist indicated that a growing body of evidence suggests that the cohorts predominantly exposed to shorter fibers (e.g., friction brake workers, gold miners, taconite miners) do not have statistically significant increased cancer risks. This panelist added that the mechanistic studies provide the strongest evidence for assigning no potency to fibrous structures (see next bulleted item). Another panelist agreed with these statements, and added that his interpretation of data compiled by the National Cancer Institute provide additional indirect evidence of short fibrous structures presenting little or no carcinogenic risk (see page 102 of the premeeting comments in Appendix B).

The panelists briefly revisited the findings from a recent publication (Suzuki and Yuen 2001) that reported finding relatively large amounts of short, thin chrysotile fibers in malignant mesothelioma tissue. Several panelists encouraged that these findings not be considered in the risk assessment methodology for reasons cited earlier in the workshop (see Section 3.2.2).

- ***Evidence from mechanistic studies.*** The panelists offered different interpretations of mechanistic studies. One panelist indicated that mechanistic studies have shown that shorter fibers are cleared more readily than long fibers from the alveolar region of the lung by phagocytosis, and therefore provide supporting evidence that short fibers play little or no role in carcinogenic risk. This panelist acknowledged that extremely high doses of particular matter and other non-fibrous structures can generate biological responses (e.g., inflammation), but he doubted that such "overload" conditions would be relevant to the environmental exposures that the proposed protocol will be used to evaluate.

  Another panelist agreed that long fibers are clearly more potent than short fibrous structures, but he questioned the conclusion that short fibrous structures have no impact on carcinogenic risk. This panelist noted that mechanistic studies have demonstrated that short fibrous structures and spherical particles, like silica, can elicit the same toxic responses (e.g., generate reactive species, stimulate proliferative factors) identified for asbestos fibers. This panelist added, referring to his premeeting comments, that exposure to short fibers could cause inflammation and generation of oxidative species that might increase the response to long fibers (see Bellman et al. 2001). Overall, this panelist acknowledged that long fibers are more persistent than short fibers in the lung and should be weighted more heavily in the exposure index, but he was hesitant to assign the short fibrous structures zero potency.

- ***Implications on sampling and analytical methods.*** One panelist commented on the practical implications, from a sampling perspective, of any changes to the exposure index. This panelist indicated that measuring all fibers (including structures shorter than 5 μm) in environmental samples would not only be expensive, but also would compromise the sensitivity of measuring the longer fibers that are most predictive of cancer risk. This panelist acknowledged that human exposure is predominantly to fibrous structures less than 5 μm, but he noted that the amounts of short fibrous structures retained by the lung tend to be very strongly

correlated with the amounts of long fibers retained by the lung. Due to this correlation, this panelist noted that measuring long fibers with sufficient accuracy would allow one to estimate amounts of short fibrous structures in a sample. This panelist added, however, that he sees no benefit of characterizing exposures to fibrous structures smaller than 5 μm, given the conclusion that such fibers do not cause cancer (ERG 2003).

4.2 Responses to Charge Question 5

Charge question 5 asks: "The proposed exposure index is weighed heavily by fibers longer than 10 μm. Specifically, Equation 7.13 suggests that the carcinogenic potency of fibers longer than 10 μm is more than 300 times greater than that of fibers with lengths between 5 and 10 μm. How consistent is this difference in carcinogenic potency with the epidemiology and toxicology literature?" The panelists' responses to this question follow:

- ***Consistency with epidemiological literature.*** The panelists noted that the original epidemiology studies did not collect exposure information that provides direct evidence of the relative potency assigned to the two different fiber length categories: fibers longer than 10 μm, and fibers with lengths between 5 and 10 μm. During this discussion, one panelist recommended that EPA consider the results of a case-control study (Rogers et al. 1991) that suggests that mesothelioma risks are greater for individuals with larger amounts of the shorter fibers (i.e., between 5 and 10 μm) retained in their lungs. Another panelist was not convinced of the findings from this study, due to possible biases from selection of controls not matched for hospital of origin. This panelist encouraged EPA to refer to more rigorous lung-retained fiber studies (e.g., McDonald et al. 1989, Rödelsperger et al. 1999) that have found that the majority of cancer risk for mesothelioma is attributed to exposures to longer fibers, even when measurements of short fibers are taken into account.

- ***Questions about the fiber length-dependence used for mesothelioma.*** Some panelists were not convinced that the relative potencies assigned to different fiber lengths were appropriate for mesothelioma. One panelist, for instance, noted that his previous review of the literature (Lippmann 1994) suggests that cancer risk for mesothelioma is most closely associated with exposure to fibers between 5 and 10 μm long. He indicated that this assessment is consistent with other human lung evaluations (e.g., Timbrell et al. 1988), which have reported that fibers retained by the lung tend to be longer than fibers that translocate to the pleura. This panelist added that the epidemiology literature clearly suggests that lung cancer and

mesothelioma have different risk factors, as the relative amounts of lung cancer and mesothelioma cases vary considerably from one cohort to the next. Based on these concerns, this panelist suggested that EPA consider developing separate fiber length weighting schemes for lung cancer and mesothelioma.

Another panelist indicated that the epidemiology studies provide indirect evidence that carcinogenic potency appears to increase with fiber length. Specifically, he noted that the studies consistently show that mesothelioma has a very long latency period—a trend that suggests that the most durable fibers (i.e., the longer fibers) are the most potent. The panelist added that the analyses in the proposed protocol provide further indirect evidence of mesothelioma risks increasing with fiber length: when the exposure index was used in the mesothelioma model, the proposed risk assessment methodology generated an improved fit to the epidemiological data.

During this discussion, a panelist cautioned about inferring that only those fibers that reach the pleura are capable of causing mesothelioma, because researchers have not determined the exact mechanisms by which mesothelioma is induced. Further, he cautioned about inferring too much from a single study (Timbrell et al. 1988), given that many additional studies are available on lung-retained fibers.

- ***Questions about the relevance of animal toxicology data.*** Some panelists expressed concern about basing the proposed weighting factors for different fiber lengths on observations from animal data. First, one panelist noted that the weighting factors were derived strictly based on lung cancers observed in laboratory animals, and he questioned whether one can assume that the weighting factors can be defensibly applied to mesothelioma. Second, other panelists noted that extrapolating the weighting factors from rodents to humans also involves uncertainty, due to inter-species differences in respiratory anatomy, macrophage sizes, and sites of lung cancers.

- ***Suggested follow-up analyses.*** Given the concerns about basing the proposed exposure index entirely on data from animal toxicology studies, two panelists recommended that EPA attempt to optimize the weighting factors applied to different fiber length categories using the available human epidemiological data. One panelist suggested that this optimization could be performed using the data compiled in Table 6-15 in the proposed protocol, which presents estimates of the fiber length distribution for different occupational cohorts. A panelist also suggested that EPA consider deriving separate weighting factors for lung cancer and mesothelioma, rather than assuming the same fiber length dependence for both outcomes.

4.3 Responses to Charge Question 6

Charge question 6 asks: "Please explain whether the proposed exposure index will allow meaningful comparisons between current environmental exposures to asbestos and historical exposures to asbestos that occurred in the work place." The panelists discussed several topics when addressing the question, because some panelists had different impressions of what the question was asking. Some panelists viewed the question as asking about the validity of low-dose linear extrapolations (see Section 3.1.5 for more information on this topic), and others viewed the question as asking about whether the proposed methodology is an improvement over EPA's current risk assessment model. A summary of the panelists' specific responses follows:

- ***Is the proposed exposure index an improvement to asbestos risk assessment?*** When answering this charge question, multiple panelists focused on whether the proposed exposure index is an improvement over EPA's 1986 asbestos risk models. These panelists agreed that the proposed approach is more consistent with the overall literature on health risks from asbestos, which show that cancer risks vary with fiber type and fiber dimension. Two panelists were hesitant to call the proposed approach an improvement for evaluating mesothelioma risks, because the fiber length weighting factors are based entirely on lung cancer data in animals. These panelists were particularly concerned that the proposed methodology might assign lower risks for mesothelioma in certain circumstances, because the fiber-length dependence in the methodology is not based on any toxicological or epidemiological studies of mesothelioma.

- ***Does the proposed risk assessment model support extrapolation from occupational exposures to environmental exposures?*** Some panelists commented on the applicability of the proposed risk assessment model to exposure doses below the ranges considered in the occupational studies. Referring to observer comments provided earlier in the workshop, two panelists indicated that some environmental exposures in areas with naturally-occurring asbestos do not appear to be considerably lower than those experienced by occupational cohorts. Another panelist agreed, and cautioned about distinguishing environmental exposures from occupational exposures; he instead encouraged EPA and the panelists to focus on the exposure magnitude, regardless of whether it was experienced in an occupational or environmental setting.

  One panelist recommended that EPA investigate how cancer risks for lung cancer and mesothelioma vary between EPA's 1986 model and the proposed risk assessment methodology: for different distributions of fiber types and dimensions, does the proposed methodology predict higher or lower risks than the 1986 model? Dr. Berman indicated that the proposed methodology, when compared to EPA's 1986 model, generally predicts substantially higher risks for environments with longer, thinner fibers and environments with larger amounts of

amphibole fibers and predicts somewhat lower risks for environments with shorter, thicker fibers and environments that contain only chrysotile fibers. One panelist recommended that future revisions to the proposed protocol include sample calculations, perhaps in an appendix, for several hypothetical environments to demonstrate how estimated cancer risks compare between the new methodology and the 1986 model.

5. COMMENTS ON TOPIC AREA 3: GENERAL QUESTIONS

This section summarizes the panelists' responses to charge questions 7–10 and 12. Responses to charge question 11 are included in Section 6, because this charge question sought the panelists' overall impressions of the proposed risk assessment methodology, rather than focusing on any one specific issue.

5.1 Responses to Charge Question 7

This charge question asks: "The proposed risk assessment approach assigns carcinogenic potency to individual fibers and to cleavage fragments (or 'bundles that are components of more complex structures'). Please comment on whether cleavage fragments of asbestos are as toxicologically significant as fibers of the same size range." The panelists raised the following points when responding:

- ***Terminology used in the charge question.*** One panelist took strong exception to the wording in this question (see pages 30–33 in Appendix B) and strongly recommended that the panelists use correct terminology during their discussions. This panelist noted, for instance, that cleavage fragments are not equivalent to bundles, nor do cleavage fragments meet the regulatory definition of asbestos, as the charge question implies. He clarified that he defines cleavage fragments as non-asbestiform amphiboles that are derived from massive amphibole structures. This panelist was concerned that none of the panelists at the workshop has the mineralogical expertise needed to address issues pertaining to cleavage fragments. Another panelist echoed these concerns and agreed that this charge question raises complex issues.

- ***Significance of cleavage fragments with respect to human health effects.*** The previous concerns notwithstanding, several panelists commented on the rôle of cleavage fragments in the proposed risk assessment methodology. One panelist, for example, indicated that there is no reason to believe that cleavage fragments would behave any differently in the human lung than asbestiform fibers of the same dimensions and durability; he added that this conclusion was also reached by the American Thoracic Society Committee in 1990 (Weill et al. 1990). This panelist acknowledged, however, that expert mineralogists have differing opinions on the role of cleavage fragments. Several other panelists agreed that it is reasonable to assume that cleavage fragments and asbestos fibers of the same dimension and durability would elicit similar toxic responses.

- ***Review of selected epidemiological and toxicological studies.*** The panelists briefly discussed what information has been published on the toxicity of cleavage fragments. One panelist indicated that Appendix B in the proposed protocol (see pages B-3 through B-10) interprets results from an animal study (Davis et al. 1991) that evaluated exposures to six tremolite samples, including some that were primarily cleavage fragments. This panelist noted that the study provides evidence that cleavage fragments can cause mesothelioma in animals.

  Another panelist, however, cautioned against inferring too much from this animal study for several reasons: the study was not peer reviewed; the fiber measurements in the study reportedly suffered from poor reproducibility; and the mesotheliomas observed in the study might have reflected use of intra-peritoneal injection model as the dose administration method. This panelist recommended that EPA conduct a more detailed review on the few studies that have examined the toxicity of cleavage fragments, possibly considering epidemiological studies of taconite miners from Minnesota (Higgins et al. 1983) and cummingtonite-grunerite miners from South Dakota (McDonald et al. 1978); he noted that a pending publication presents updated risks among the taconite miners.

- ***Practical implications of measuring cleavage fragments in environmental samples.*** One panelist added, and another agreed, that measuring cleavage fragments in environmental samples presents some challenges, because microscopists cannot consistently distinguish cleavage fragments from asbestiform fibers, even when using TEM.

5.2 Responses to Charge Question 8

Charge question 8 asks: "Please comment on whether the proposed cancer assessment approach is relevant to all amphibole fibers or only to the five types of amphibole fibers (actinolite, amosite, anthophyllite, crocidolite, tremolite) designated in federal regulations." The panelists made the following general comments in response:

- ***Review of evidence from toxicological and epidemiological studies.*** The panelists identified few studies that address the toxicity of amphibole fibers other than actinolite, amosite, anthophyllite, crocidolite, and tremolite. One panelist indicated that animal toxicology studies have demonstrated that synthetic vitreous fibers with differing chemistry, but having similar durability and dimensions, generally exhibit similar potency for fibrosis, lung cancer, and mesothelioma. Another panelist added that lung cancer and mesothelioma exposure-response

relationships for a cohort of vermiculite miners from Libby, Montana, have been published for both asbestiform richterite and winchite.

- ***Appropriateness of applying the model to non-asbestiform amphiboles.*** Several panelists agreed that the proposed risk assessment methodology is relevant to amphibole fibers other than those listed in the federal regulations. The panelists noted that, in the absence of more detailed information on the matter, it is prudent to assume that fibers of similar dimension and durability will exhibit similar toxic effects. Two panelists expressed some hesitation on applying the proposed model to the non-asbestiform amphiboles: one panelist asked how confidently one can apply the cancer risk coefficients to amphibole fibers that have not been studied, and another panelist indicated he was not convinced that the model should be applied to the other amphiboles, let alone for the amphiboles that are listed in the federal regulations.

  Given the amount of naturally occurring amphiboles in the Earth's crust, one panelist suggested that the proposed protocol clearly state that the non-asbestiform amphiboles being evaluated are only those with the same dimensional characteristics and biodurability as the corresponding asbestiform amphiboles.

5.3 Responses to Charge Question 9

Charge question 9 asks: "The review document recommends that asbestos samples be analyzed by transmission electron microscopy (TEM) and count only those fibers (or bundles) longer than 5 μm. Such counting practices will provide no information on the amount of asbestos fibers shorter than 5 μm. To what extent would data on shorter fibers in samples be useful for future evaluations (e.g., validation of the cancer risk assessment methodology, assessment of non-cancer endpoints)?"

The panelists expressed varying opinions on this matter: some panelists saw no benefit of measuring fibrous structures shorter than 5 μm, based on responses to earlier charge questions (see Sections 3.1.3, 3.1.4, and 4.1); other panelists indicated that there is some utility to collecting information on shorter fibrous structures, particularly if the incremental analytical costs are not prohibitively expensive and if counting short fibers does not compromise accurate counts of longer fibers. The panelists raised the following specific issues when discussing measurement methods:

- ***Support for using TEM in future sampling efforts.*** The panelists unanimously supported the recommendation in the proposed protocol of using TEM, rather than PCM or some other method, to characterize exposures in future risk assessments. The panelists also emphasized that future measurement methodologies must focus on generating accurate counts of the most biologically active fibers, or fibers longer than 5 µm.

- ***Practical implications of counting fibers shorter than 5 µm.*** One panelist indicated that analyzing samples for fibrous structures shorter than 5 µm would compromise analysts' ability to accurately count the amounts of longer fibers that are of greater biological concern. Some panelists and an observer further discussed the costs associated with counting fibers in multiple length categories, including shorter than 5 µm. The panelists did not cite firm cost figures for these analyses. However, noting that environmental samples typically contain more than 90% short fibrous structures, one panelist suspected that counting the shorter structures would considerably increase the time a microscopist needs to analyze samples, and therefore also would considerably increase the cost of the analysis. A panelist indicated that the costs and benefits of counting fibers shorter than 5 µm might be more appropriately debated between microscopists and risk assessors, with inputs from industrial hygienists and mineralogists.

- ***Relevance of fibers shorter than 5 µm for non-cancer endpoints.*** One panelist noted that exposures to fibrous structures shorter than 5 µm can contribute to asbestosis in occupationally exposed individuals (Lippmann 1988), but he doubted that the exposure levels found to be associated with asbestosis would be experienced in non-occupational settings. Another panelist added that the role of shorter fibrous structures for other non-cancer endpoints is not known, such as the pleural abnormalities and active pleural fibrosis observed in Libby, Montana. No panelists were aware of any authoritative statements made on the role that short fibers play, if any, on these other non-cancer endpoints. During this discussion, one panelist indicated that the toxicity of fibrous structures shorter than 5 µm might be adequately addressed by EPA's particulate matter standards.

5.4 Responses to Charge Question 10

Charge question 10 asks: "The proposed risk assessment methodology suggests that exposure estimates should be based only on fibers longer than 5 µm and thinner than 0.5 µm. Is this cut-off for fiber diameter appropriate?" Before the panelists responded to the question, Dr. Berman first clarified that the exposure index optimized from the animal studies (see Equation 7.12 in the proposed protocol)

assigns a far greater carcinogenic potency to fibers longer than 40 μm, with diameters less than 0.4 μm; he noted that the proposed diameter cut-off (0.5 μm) was based on an *ad hoc* adjustment.

The panelists agreed that the proposed cut-off for fiber diameter (0.5 μm) would likely include most fibers of health concern; however, they also unanimously agreed that the exposure index should not exclude thicker fibers that are known to be respirable in humans. The main argument given for increasing the cut-off is that fibers with diameters as large as 1.5 μm (or with aerodynamic diameters as large as 4.5 μm) can penetrate to small lung airways in humans. Other panelists provided additional specific comments, generally supporting inclusion of thicker fibers in the proposed exposure index. One panelist, for example, advised against basing the fiber diameter cut-off strictly on observations from rat inhalation studies, due to inter-species differences in respirability. Further, noting that the proposed cut-off for fiber diameter would likely exclude some amosite fibers and a considerable portion of tremolite fibers with known carcinogenic potency, another panelist encouraged that the proposed exposure index include contributions from thicker fibers.

The panelists noted that consideration of fibers thicker than 0.5 μm was viewed as being most important for the lung cancer risk assessment model, as risks for mesothelioma appear to be more closely linked to exposures to long, thin fibers (see Section 3.2.3). Further, some panelists suspected that increasing the fiber diameter cut-off in the exposure index should be accompanied by changes to the exposure-response coefficients in the risk assessment models, but the panelists did not unanimously agree on this issue.

5.5. Responses to Charge Question 12

Charge question 12 asks: "Section 8.2 of the review document presents three options for assessing cancer risks from asbestos exposure. Please comment on the technical merit of the proposed risk assessment options." The panelists briefly reviewed the strengths and weaknesses of the three options presented in the proposed protocol for assessing asbestos-related cancer risks. The panelists agreed that the first option—direct use of EPA's lung cancer and mesothelioma risk assessment models—allows for the greatest flexibility in evaluating site-specific exposure scenarios, particularly those with time-varying exposures. Dr. Crump indicated that he envisioned this option being coded into a computer program, into which users enter their site-specific exposure information. Most panelists endorsed developing such a program. The panelists did not reject use of the second and third options, provided that EPA ensures that all three options generate equivalent risk estimates for the same exposure scenario.

The one issue discussed in greater detail was how sensitive predictions using the first option are to the mortality rates used in the evaluation. Noting that mortality rates as functions of age and sex differ from one location to the next, this panelist encouraged EPA to consider carefully whether nationwide mortality estimates would be programmed into the risk assessment model or whether risk assessors would have the option of entering site-specific mortality rates. The panelist also suggested that the authors of the risk assessment conduct sensitivity analyses to quantify how strongly the mortality data affect cancer risk estimates. These comments also raised questions about the fact that two populations with different underlying mortality rates could have different cancer risks, even though their asbestos exposure levels are equivalent.

6. COMMENTS ON TOPIC AREA 4: CONCLUSIONS AND RECOMMENDATIONS

This section reviews the panelists' individual conclusions and recommendations regarding the proposed protocol (Section 6.1), as well as how the panelists developed their overall conclusions and recommendations that appear in the executive summary of this report (Section 6.2).

6.1 Responses to Charge Question 11

Charge question 11 asks: "Discuss whether the proposed cancer assessment approach, as a whole, is a reasonable evaluation of the available health effects data. What aspects of the proposed cancer assessment approach, if any, are inconsistent with the epidemiology or toxicology literature for asbestos?" The panelists offered individual summary statements, which were not discussed or debated among the panel. Following is a summary of the panelists' individual summary statements in the order they were given:

- ***Dr. Lippmann's summary statement.*** Dr. Lippmann commended Drs. Berman and Crump on developing the proposed risk assessment protocol and supported use of a model that accounts for the factors (e.g., fiber type and dimension) that are most predictive of cancer risk. Dr. Lippmann supported the authors' attempt to make full use of the existing data and to interpret the results from the epidemiological studies. He strongly recommended that EPA make every effort to obtain individual-level data from additional epidemiological studies. Dr. Lippmann suggested that a follow-up workshop with experts in exposure assessment could help EPA evaluate the uncertainties in exposure measurements from historic occupational data sets. Dr. Lippmann supported an observer's suggestion to conduct an animal inhalation study using tremolite cleavage fragments to help resolve the issue of these fragments' carcinogenic potency. Overall, he encouraged that future work on the proposed protocol continue, through use of additional expert panels, to make more informed usage of the human exposure data.

- ***Dr. Teta's summary statement.*** Dr. Teta indicated that the proposed protocol is an impressive integration of the animal toxicology data and the human epidemiology data. She commended the authors for developing a scientific methodology that successfully reduces the variability in results across the epidemiological studies, suggesting that the studies might be more consistent than were previously thought. Dr. Teta recommended improvements to the meta-analysis of

epidemiological studies, such as establishing and applying criteria for use of human data in characterizing exposure-response relationships. Overall, Dr. Teta found no inconsistencies between the proposed protocol and the larger body of epidemiology literature, including studies of cohorts (e.g., gas mask workers, railroad workers, friction brake workers) that do not have well-defined exposure information. Though not disagreeing with the utility of other panelists' recommendations, such as re-analyzing data from additional epidemiological studies and convening additional expert panels, Dr. Teta encouraged EPA to move forward expeditiously with completing the proposed protocol and discouraged implementing additional steps that might delay the overall project.

- ***Dr. Hoel's summary statement.*** Dr. Hoel encouraged the use of more sophisticated modeling that incorporates data on exposure-response (including non-linear models), duration of exposure, cessation of exposure, and uncertainty in exposure. Dr. Hoel also strongly recommended that EPA attempt to obtain individual-level data from additional epidemiology studies, or at least obtain partial data sets. He encouraged Drs. Berman and Crump to use more sophisticated uncertainty analysis techniques, such as generating prior and posterior distributions of uncertainty. To ensure that the lung cancer model is not confounded by cigarette smoking, Dr. Hoel recommended that Drs. Berman and Crump more closely evaluate all available data on the interactions between asbestos exposure and cigarette smoking.

- ***Dr. Steenland's summary statement.*** Dr. Steenland indicated that the proposed protocol is a step forward in asbestos risk assessment; however, he had several recommendations for improving the analysis of epidemiological studies. For instance, Dr. Steenland suggested that the authors conduct meta-regression analyses using the original exposure-response coefficients, in which predictor variables include fiber size, fiber type, the estimated percentage of amphiboles, percentage of fiber greater than 10 μm, and categorical grouping of studies according to quality. He indicated that these factors can be examined using both fixed effects and random effects models. Dr. Steenland recommended that the proposed protocol explicitly state and defend the basis for choosing the 10 μm cut-off for fiber length in the exposure index. He suggested that EPA should consider using Bayesian techniques or other methods to determine which relative potencies assigned to different fiber length categories optimize the model's fit to the epidemiological data.

  Focusing on specific topics, Dr. Steenland indicated that he disagrees with the approach of assigning amphibole fibers five times greater lung cancer potency than chrysotile fibers, especially considering that the statistical analysis in the proposed protocol could not reject the hypothesis that amphibole fibers and chrysotile fibers are equally potent. Further, he advocated suggestions of exploring the adequacy of other exposure-response models (e.g., non-linear models). Finally, Dr. Steenland suspected that cigarette smoking likely will not be a confounding factor in exposure-response analyses for two reasons. First, he noted that differences in smoking practices between working populations and general populations typically do not cause

substantial differences in standardized mortality ratios. Second, he indicated that it is highly unlikely that prevalence of smoking varies with workers' exposure levels. Dr. Steenland encouraged that EPA refer to a recent publication (Liddell and Armstrong 2002) for similar insights on interactions between asbestos exposure and cigarette smoking.

- ***Dr. Crapo's summary statement.*** Dr. Crapo complimented Drs. Berman and Crump on preparing the cancer risk assessment methodology, and he supported the general approach of expressing cancer risk as a function of asbestos fiber type and fiber dimension. Dr. Crapo indicated that the proposed protocol reaches several defensible conclusions, such as assigning greater mesothelioma potency to amphibole fibers and to longer fibers while assigning no risk to fibers less than 5 μm in length. However, he was concerned about some specific issues that are not yet adequately resolved. For instance, Dr. Crapo felt additional data are needed to rigorously define how mesothelioma potency varies with fiber length (i.e., fibers longer than 10 μm being 300 times more potent than fibers with lengths between 5 and 10 μm). Dr. Crapo recommended that EPA, when revising the proposed protocol, explore more sophisticated modeling techniques, including non-linear exposure-response models and consideration threshold effects. He supported more detailed analyses of interactions between asbestos exposure and cigarette smoking, again through the use of non-linear models.

- ***Dr. Sherman's summary statement.*** Dr. Sherman first indicated that she concurred with several recommendations made by Drs. Hoel and Steenland. She focused her summary statements on the proposed exposure index, recommending that Drs. Berman and Crump use the epidemiology data to further investigate other formulations of an exposure index. Dr. Sherman recommended, for example, examining the goodness of fit of other formulations of the exposure index (e.g., assigning zero potency to all fibers shorter than 10 μm). Further, she recommended that the authors attempt to optimize the potency weighting factors in the exposure index to the epidemiological data. Finally, given that panelists expressed concern regarding how potency varies with fiber length for mesothelioma, Dr. Sherman suggested that Drs. Berman and Crump consider developing two different exposure indexes—one optimized for lung cancer, and the other for mesothelioma. Dr. Sherman added that she generally supported the lung cancer and mesothelioma exposure-response models, and questioned whether using more complicated models would necessarily lead to a better understanding of the data.

- ***Dr. Castranova's summary statement.*** Dr. Castranova concluded that the proposed protocol is a significant advance in asbestos risk assessment methodology. He strongly supported the recommendation that future measurements be performed using TEM, rather than PCM. Dr. Castranova also supported the approach of assigning equal carcinogenic potency to cleavage fragments and asbestos fibers of similar dimension—a finding, he noted, that could be tested in an animal inhalation study. Further, Dr. Castranova agreed that non-asbestiform amphiboles and asbestos amphiboles of the same dimension should be assigned equal carcinogenic potency. Dr. Castranova indicated that the epidemiology and toxicology literature clearly indicate that

mesothelioma potency varies with fiber type, but he was not convinced that this literature supports a difference in lung cancer potency between amphibole and chrysotile fibers.

- ***Dr. Price's summary statement.*** Dr. Price found the proposed protocol to be an impressive compilation of the epidemiology and toxicology literature into a cancer risk assessment model that addresses most, but not all, risk factors debated since EPA's 1986 model. Dr. Price urged EPA to explore exposure-response models other than the models that involve linear, low-dose extrapolations, which he viewed as being inconsistent with the epidemiology literature. Dr. Price indicated that future revisions to the protocol should definitely consider non-linear models and threshold effects.

  As an additional comment, Dr. Price emphasized that the two main elements of the protocol—the proposed exposure index and the exposure-response analysis—are closely inter-related and subsequent changes to the proposed exposure index could affect the robustness of the overall modeling effort. As an example of his concern, Dr. Price noted that increasing the fiber diameter cut-off in the exposure index from 0.5 μm to 1.5 μm could (according to an observer comment) lead to dramatic differences in the number of cleavage fragments counted in environment samples; however, he indicated that the animal studies used to derive the original exposure index did not include cleavage fragments. Such scenarios raise questions about using an exposure index derived from very specific exposure conditions in animal studies to evaluate human health risks associated with exposures of an entirely different character. Dr. Price encouraged further study of cleavage fragments, perhaps in an animal inhalation study, to resolve the role of cleavage fragments.

- ***Dr. Case's summary statement.*** Dr. Case congratulated Drs. Berman and Crump for compiling what he viewed as a reasonable evaluation of the available toxicology and epidemiology literature, and he strongly supported the general approach of factoring fiber type and fiber dimension into cancer risk assessment. Dr. Case indicated that he agreed with the finding that amphibole fibers have slightly greater lung cancer potency than do chrysotile fibers, although he believed that fiber dose, fiber length, and especially smoking history and type of industry have greater importance in this regard. Dr. Case recognized that how one views the differences between the Quebec and South Carolina cohorts affects the conclusions drawn on this issue, and he encouraged EPA to classify the cohort of South Carolina textile workers as being exposed to mixed asbestos fibers, rather than being exposed to only chrysotile fibers.[2]

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[2] When presenting the summary statements, one panelist (LS) indicated that NIOSH is re-analyzing filters that were collected in the 1960s from the South Carolina textile plant, and these re-analyses should indicate the distribution of fiber types in this cohort's exposures. Another panelist (BC) noted that these re-analyses will not characterize earlier exposures to amosite fibers, which are believed to have occurred primarily before 1950 (based on findings from studies of lung-retained fibers).

Dr. Case made several recommendations for further evaluating the existing epidemiological data and for collecting additional data. First, Dr. Case indicated that it is critically important for any lung cancer risk model to consider confounding effects of cigarette smoking, and he encouraged EPA to incorporate interactions with cigarette smoking into the lung cancer model to the greatest extent possible. Second, Dr. Case supported Dr. Lippmann's recommendation of convening an additional expert panel workshop to critically review inferences that should be drawn from the exposure measurements made in the epidemiological studies; such a panel, Dr. Case noted, would require inputs from experts in mineralogy, industrial hygiene, and measurement methodologies. Third, he supported comments recommending that EPA examine non-linear and threshold exposure-response models. Finally, Dr. Case agreed that conducting an animal inhalation study is probably the best way to examine whether tremolite cleavage fragments produce lung cancer, but did not advocate using rat inhalation studies to examine whether these fragments induce mesothelioma, because results from rat inhalation studies have been shown to be a poor model for mesothelioma in humans. He added, however, that it would quite probably be impossible to design an experiment in which rats were exposed only to "cleavage fragments" or "non-asbestiform fibers" with no asbestiform fibers present at all.

- ***Dr. Stayner's summary statement.*** Dr. Stayner supported the general concept of incorporating fiber type and fiber dimension into cancer risk assessment, but he recommended that additional work be conducted before EPA accepts the proposed protocol as a new risk assessment paradigm. Dr. Stayner indicated that his confidence in the proposed protocol varies between the lung cancer and mesothelioma models.

  For lung cancer, Dr. Stayner indicated that the available epidemiological data should be able to support a new risk assessment model, but he recommended that EPA consider the panelists' many recommendations for how the meta-analysis can be improved (e.g., using different statistical models, developing and applying minimal study inclusion criteria, conducting additional sensitivity analyses). Concurring with Dr. Steenland's summary statement, Dr. Stayner added that cigarette smoking is very unlikely to be a confounding factor in the lung cancer model and he questioned whether the available data would support a quantitative assessment of the interaction effects. While Dr. Stayner supported the recommendation for evaluating non-linear exposure-response models, he noted that the individual-level data needed to construct these models are not available for most epidemiological studies. Dr. Stayner added that obtaining raw data from additional occupational cohorts would provide the best opportunity for more detailed exploration of non-linear exposure-response relationships.

  Dr. Stayner expressed greater concern about the foundation of the mesothelioma risk model. He indicated, for instance, that the relative potencies included in the proposed exposure index are based entirely on toxicology studies for lung cancer, and not on any epidemiology or toxicology studies specific to mesothelioma. Despite these concerns about the biological basis for the proposed mesothelioma model, Dr. Stayner noted that the proposed model does provide an

improved fit to the findings from the epidemiological studies. He recommended that EPA consider optimizing the relative potencies in the exposure index to the human data, especially if EPA can access raw data from additional occupational cohorts to evaluate how exposure-response varies with fiber size and fiber type.

- ***Dr. McClellan's summary statement.*** Dr. McClellan congratulated Drs. Berman and Crump for integrating the toxicological and epidemiological data into a reasonable evaluation of asbestos cancer risks. Overall, Dr. McClellan found the proposed protocol to be a substantial improvement over EPA's 1986 models and urged EPA to continue to move forward with completing the protocol based on the panelists' feedback. Though he found the presentation of information in the draft document to lack transparency on many important matters, Dr. McClellan indicated that the authors' presentations at the workshop addressed many of his concerns regarding the transparency of how the proposed model was developed. One suggested improvement to the protocol's transparency was to clearly describe what literature were reviewed and to specify what studies actually factored into the quantitative analyses.

  Addressing specific topics, Dr. McClellan indicated that the analyses in the proposed protocol adequately characterize the general roles that fiber type and fiber dimension play in cancer risk. He supported suggestions for involving additional experts, perhaps in another expert panel review, to further review interpretations of the epidemiological studies. Further, Dr. McClellan agreed with other panelists' recommendation that EPA explore the utility of non-linear exposure-response models, consistent with the agency's proposed revised Cancer Risk Assessment Guidelines. If linear, low-dose extrapolation models are ultimately used, he suggested that EPA explicitly acknowledge the uncertainties associated with such an approach. Dr. McClellan indicated that obtaining raw data from additional epidemiological studies might be particularly helpful in the exposure-response modeling. Finally, Dr. McClellan emphasized that the exposure characterization in the proposed protocol is closely linked to the exposure-response assessment; thus, the authors must carefully consider how revisions to the exposure characterization affect the assumptions in the exposure-response assessment, and vice versa.

6.2 Development of Final Conclusions and Recommendations

After presenting their individual conclusions and recommendations, the panelists worked together to draft summary statements for the peer consultation workshop. Every panelist was asked to write a brief synopsis of a particular topic debated during the workshop. These draft statements were then displayed to the entire panel and observers, edited by the panelists, and then compiled into this document's

executive summary, which should be viewed as the expert panel's final conclusions and recommendations regarding the proposed protocol.

7. REFERENCES

B Bellmann, H Muhle, O Creutzenberg, et al. 2001. Effects of nonfibrous particles on ceramic fiber (RCF1) toxicity in rats. Inhalation Toxicology 13(10):877–901.

DW Berman, KS Crump, EJ Chatfield, JMG Davis, AD Jones. 1995. The Sizes, Shapes, and Mineralogy of Asbestos Structures that Induce Lung Tumors or Mesothelioma in AF/HAN Rats Following Inhalation. Risk Analysis 15(2).

DW Berman and KS Crump 1999. Methodology for Conducting Risk Assessments at Asbestos Superfund Sites; Part 1: Protocol. Final Draft. Prepared for U.S. Environmental Protection Agency. February 15, 1999.

DW Berman and KS Crump 2001. Technical Support Document for a Protocol to Assess Asbestos-Related Risk. Final Draft. Prepared for U.S. Environmental Protection Agency and U.S. Department of Transportation. September 4, 2001.

G Berry and ML Newhouse. 1983. Mortality of Workers Manufacturing Friction Materials Using Asbestos. British Journal of Industrial Medicine 40:1–7.

C Boutin, P Dumortier, F Rey, et al. 1996. Black spots concentrate oncogenic asbestos fibers in the parietal pleura. American Journal of Respiratory Critical Care and Medicine 153:444–449.

M Camus, J Siematycki, B Meek. 1998. Nonoccupational exposure to chrysotile asbestos and the risk of lung cancer. New England Journal of Medicine 338:1565–1571.

WC Cooper, O Wong, and R Graebner. 1988. Mortality of workers in two Minnesota taconite mining and milling operations. Journal of Occupational Medicine 30(6):506–511.

JMG Davis, J Addison, C McIntosh, BG Miller, and K Niven. 1991. Variations in the Carcinogenicity of Tremolite Dust Samples of Differing Morphology. Annals of the New York Academy of Sciences, 473–490.

PE Enterline, J Harley, and V Henderson. 1986. Asbestos and Cancer—A Cohort Followed to Death. Graduate School of Public Health, University of Pittsburgh.

N De Klerk, B Armstrong, A Musk, M Hobbs. 1989. Cancer mortality in relation to measures of exposure to crocidolite at Wittenoom Gorge in Western Australia. British Journal of Industrial Medicine 46:529–536.

JM Dement, DP Brown, A Okun. 1994. Follow-up Study of Chrysotile Asbestos Textile Workers: Cohort Mortality and Case-Control Analysis. American Journal of Industrial Medicine 26:431–447.

EPA 1986. Airborne Asbestos Health Assessment Update. U.S. Environmental Protection Agency. EPA 600/8-84-003F. 1986.

ERG. 2003. Report on the Expert Panel on Health Effects of Asbestos and Synthetic Vitreous Fibers: The Influence of Fiber Length. Prepared by Eastern Research Group, Inc., for the Agency for Toxic Substances and Disease Registry. March 17, 2003.

TW Hesterberg, GA Hart, J Chevalier, et al. 1998. The importance of fiber biopersistence and lung dose in determining the chronic inhalation effects of X607, RCF1, and chrysotile asbestos in rats. Toxicology and Applied Pharmacology 153:68–82.

ITT Higgins, JH Glassman, MS Oh, and RG Cornell. 1983. Mortality of reserve mining company employees in relation to taconite dust exposure. American Journal of Epidemiology 118(5):710–719.

J Hodgson and A Darnton. 2000. The Quantitative Risk of Mesothelioma and Lung Cancer in Relation to Asbestos Exposure. Annals of Occupational Hygiene 44(8):565–201.

JM Hughes, H Weill, YY Hammad. 1987. Mortality of Workers Employed at Two Asbestos Cement Plants. British Journal of Industrial Medicine 44:161–174.

IARC. 1996. AB Kane, P Boffetta, R Saracci, and JD Wilbourn. Mechanisms of Fibre Carcinogenesis. International Agency for Research on Cancer. Oxford University Press 140:1–9.

JL Levin, JW McLarty, GA Hurst, AN Smith, and AL Frank. 1998. Tyler Asbestos Workers: Mortality Experience in a Cohort Exposed to Amosite. Occupational and Environmental Medicine 55:155–160.

FD Liddell and BG Armstrong. 2002. The combination of effects on lung cancer of cigarette smoking and exposure in Quebec chrysotile miners and millers. Annals of Occupational Hygiene 46(1):5–13.

FD Liddell, AD McDonald, and JC McDonald. 1997. The 1891-1920 Birth Cohort of Quebec Chrysotile Miners and Millers: Development from 1904 and Mortality to 1992. Annals of Occupational Hygiene 41:13–36.

FD Liddell, AD McDonald, and JC McDonald. 1998. Dust exposure and lung cancer in Quebec chrysotile miners and millers. Annals of Occupational Hygiene 42(1):7–20.

M Lippmann. 1988. Review: Asbestos exposure indices. Environmental Res 46:86–106.

M Lippmann. 1994. Deposition and retention of fibers: Effects on incidence of lung cancer and mesothelioma. Occupational and Environmental Medicine 51:793–798.

JC McDonald, GW Gibbs, FD Liddell, and AD McDonald. 1978. Morality after long exposure to cummingtonite-grunerite. American Review of Respiratory Disease 118(2):271–277.

AD McDonald, JS Fry, AJ Woolley, and JC McDonald. 1984. Dust Exposure and Mortality in an American Chrysotile Asbestos Friction Products Plant. British Journal of Industrial Medicine 41:151–157.

JC McDonald, B Armstrong, B Case, et al. 1989. Mesothelioma and asbestos fiber type. Evidence from lung tissue analysis. Cancer 63:1544–1547.

AD McDonald, BW Case, A Churg, A Dufresne, GW Gibbs, P Sebastien, and JC McDonald. 1997. Mesothelioma in Quebec chrysotile miners and millers: epidemiology and aetiology. Annals of Occupational Hygiene 41(6):707–719.

JC McDonald, J Harris, and B Armstrong. 2002. Cohort mortality study of vermiculite miners exposed to fibrous tremolite: an update. Annals of Occupational Hygiene 46(S1):93–94.

WJ Nicholson. 1976. Part III: Recent Approaches to the Control of Carcinogenic Exposures. Case Study 1: Asbestos—The TLV Approach. Annals of New York Academy of Science 271:152–169.

C-G Ohlson, T Rydman, L Sundell, et al. 1984. Decreased lung function in long-term asbestos cement workers: A cross-sectional study. American Journal of Industrial Medicine 5:359–366.

K Rödelsperger, H-J Woitowitz, B Brückel, et al. 1999. Dose-response relationship between amphibole fiber lung burden and mesothelioma. Cancer Detection and Prevention 23(3):183–193.

AJ Rogers, J Leigh, G Berry, et al. 1991. Relationship between lung asbestos fiber type and concentration and relative risk of mesothelioma. Cancer 67:1912–1920.

A Rogers and G Major. 2002. Letter to the Editor: The Quantitative Risks of Mesothelioma and Lung Cancer in Relation to Asbestos Exposure: The Wittenoom Data. Annals of Occupational Hygiene 46(1):127–129.

H Seidman, IJ Selikoff, and SK Gelb. 1986. Mortality Experience of Amosite Asbestos Factory Workers: Dose-Response Relationships 5 to 40 Years after onset of Short-Term Work Exposure. American Journal of Industrial Medicine 10:479–514.

IJ Selikoff and H Seidman. 1991. Asbestos-Associated Deaths among Insulation Workers in the United States and Canada, 1967–1987. Annals of the New York Academy of Sciences 643:1–14.

LT Stayner, DA Dankovic, RA Lemen. 1996. Occupational Exposures to Chrysotile Asbestos and Cancer Risk: A Review of the Amphibole Hypothesis. American Journal of Public Health 86(2):176–186.

V Timbrell, T Ashcroft, B Goldstein, et al. 1988. Relationships between retained amphibole fibers and fibrosis in human lung tissue specimens. In: Inhaled Particles VI. Annals of Occupational Hygiene 32(S1):323–340.

Y Suzuki and S Yuen. 2001. Asbestos Tissue Burden Study on Human Malignant Mesothelioma. Industrial Health 39:150–160.

MJ Teta, HC Lewinsohn, JW Meigs, et al. 1983. Mesothelioma in Connecticut: 1955–1977: Occupational and geographic associations. Journal of Occupational Medicine 25(10):749–756.

A Tossavainen, M Kotilainen, K Takahashi, G Pan, and E Vanhala. 2001. Amphibole Fibers in Chinese Chrysotile Asbestos. Annals of Occupational Hygiene 45(2):145-152.

H Weill, JL Abraham, JR Balmes, B Case, AM Churg, J Hughes, M Schenker, and P Sebastien. 1990. Health Effects of Tremolite. Official statement of the American Thoracic Society. American Review of Respiratory Disease 142(6):1453–1458.

E Yano, ZM Wang, XR Wang, MZ Wang, and YJ Lan. 2001. Cancer Mortality among Workers Exposed to Amphibole-free Chrysotile Asbestos. American Journal of Epidemiology 154(6):538–543.

The following Appendices:

Appendix A - List of Expert Panelists
Appendix B - Consultants' Premeeting Comments
Appendix C - List of Registered Observers
Appendix D - Agenda
Appendix E - Observer Comments Provided at the Peer Consultation Workshop
Appendix F - Observer Post-Meeting Comments

Are available at: http://www.epa.gov/superfund/programs/risk/asbestos/index.htm

Appendix A

List of Expert Panelists

Appendix B

Premeeting Comments, Alphabetized by Author
(includes bios of panelists and the charge to the panelists)

Note: This appendix is a copy of the booklet of the premeeting comments that ERG distributed at the peer consultation workshop. One panelist (Dr. Bruce Case) submitted an edited form of his premeeting comments to ERG at the workshop. That edited version appears in this appendix.

Appendix C

List of Registered Observers of the Peer Consultation Workshop

Appendix D

Agenda for the Peer Consultation Workshop

Appendix E

Observer Comments Provided at the Peer Consultation Workshop

Note: The peer consultation workshop included three observer comment periods, one on the first day of the workshop and two on the second day of the workshop. This appendix includes verbatim transcripts (to the extent that specific remarks were audible from recordings) of the observer comments, in the order the comments were given.

Appendix F

Observer Post-Meeting Comments

APPENDIX C:
COMPENDIUM OF MODEL FITS TO ANIMAL INHALATION DATA IN SUPPORT OF THE BERMAN ET AL. (1995) STUDY AND POST-STUDY WORK

The attached tables are a compendium of raw outputs for the fits of various (exposure index) models to the Davis et al. animal inhalation studies. Each entry lists the date of the run, the size categories included in the run, the maximum likelihood estimate for the run, the degrees of freedom, the P-value for the fit, and the coefficients representing the relative potency assigned to each size category for the model.

```
                                                                                                                MLE        ChiSquare  DF  P-Value    Coefficients?
                                                    Equation?
 "05/29/1992" "17:52:38" "PS PCM <5, 5-10, 10-20, >20                                                     "  -62.1949      18.14     11  7.8315E-02  .0000       .0000
.7472      5.2207E-03  6.7064E-05
 "05/29/1992" "17:52:42" "SC PCM  20-30, >30,  <0.1,  0.1-0.2,  0.2-0.3,  0.3-0.4,  >0.4                  "  -60.5687      13.56      8  9.4038E-02  .0000       .2042
.0000      3.7528E-02  .0000      .0000      .0000      .5381      3.7282E-11  4.3022E-03  5.1364E-03
 "05/29/1992" "17:53:01" "SC PCM  20-30, 30-40 >40                                                        "  -60.7224      13.89     10   .1782      7.6677E-02  3.2929E-13
5.1206E-03  6.2222E-04
 "05/29/1992" "17:53:06" "SC PCM  20-30, >30, AR<10<AR<20<AR                                              "  -60.9782      14.77     10   .1407       .0000       .7915
.2085      .0000      4.1600E-13  3.7200E-03  1.2185E-03
 "05/29/1992" "17:53:16" "SC PCM  <20, 20-40, 40-60, >60                                                  "  -61.1790      15.12     11   .1772       .0000       1.000
2.0226E-11  4.2164E-03  1.8379E-04
 "05/29/1992" "17:53:23" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, 5-60, >60, <0.2, >0.2              "  -60.1211      13.15     10   .2155       .0000       .0000
.0000      .0000      .0000      .0000      .7552      .0000      .0000      .2448      .0000      .0000      .0000      .0000      1.3025E-10  2.9064E-03  2.4831E-03
 "05/29/1992" "17:53:42" "SC PCM 10-20, 20-30, 30-40, >40, AR<100, 100-200, AR>200                        "  -59.8032      12.80      8   .1189       .0000       .2092
.0000      .0000      .0000      .2265      8.0142E-02  .0000      .4841      .0000      -6.0482E-08  4.1242E-03  6.7554E-03
 "05/29/1992" "17:54:06" "SC PCM <5, 5-10, 10-20, >20                                                     "  -61.7831      17.00     11   .1080       .0000       .0000
.7619      4.7177E-03  7.9308E-05
 "05/29/1992" "17:54:11" "PS PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, 50-60, >60, <0.2, >0.2             "  -59.6135      12.25      7  9.2727E-02  .0000       .0000
.0000      .0000      2.7635E-02  4.6469E-04  .5748      .0000      .3849      1.2251E-02  .0000      .0000      .0000      .0000      -1.5614E-08  5.6502E-03  9.6600E-03
 "05/29/1992" "17:55:00" "PS(no C or M)PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, 50-60, >60, <0.2, >0.2  "  -59.5425      13.53      8  9.4748E-02  .0000       .0000
.0000      .0000      1.7508E-02  4.3916E-02  .6920      .2466      .0000      .0000      .0000      .0000      .0000      .0000      1.9732E-10  4.4931E-03  1.5296E-03
 "05/29/1992" "17:55:34" "SC(no C or M)PCM <5, 5-10, 10-2, 20-30, 30-40, 40-50, 50-60, >60, <0.2, >0.2   "  -60.5424      14.20      9   .1155       .0000       .0000
.0000      .0000      .0000      7.8183E-03  .6538      .0000      .0000      .3383      .0000      .0000      .0000      .0000      -2.8277E-10  3.8208E-03  1.8162E-03
 "05/29/1992" "17:55:52" "SC PCM 20-30, 30-40, 40-50, <0.15,  0.15-0.25,  0.25-0.35,  >0.35               "  -59.1475      11.74      6  6.7916E-02  .1315       .0000
.0000      3.6828E-03  3.8012E-05  .0000      .0000      1.4520E-02  .0000      .3824      -1.7330E-08  4.4091E-03  1.9861E-02
 "05/29/1992" "17:56:15" "PS PCM 20-30, 30-40, 40-50, <0.15,  0.15-0.25,  0.25-0.35,  >0.35               "  -59.3960      12.11     10   .2776       .0000       .0000
.8224      .0000      .0000      .0000      .0000      .1776      .0000      .0000      4.3492E-10  4.2216E-03  2.6240E-03
 "05/29/1992" "17:56:20" "PS(no C or M)PCM 20-30, 30-40, 40-50, <0.15,  0.15-0.25,  0.25-0.35,  >0.35    "  -59.8255      13.54      5  1.8790E-02  .1467       .0000
1.2200E-02  .2542      .1467      .0000      .0000      .0000      .1467      .1467      3.5740E-11  3.4723E-03  4.9456E-03
 "05/29/1992" "17:56:25" "SC(no C or M)PCM 20-30, 30-40, 40-50, <0.15,  0.15-0.25,  0.25-0.35,  >0.35    "  -58.9800      11.67      7   .1120      9.8451E-02  .0000
.0000      9.7985E-03  .0000      .0000      .0000      1.5661E-03  .0000      .4401      -3.8840E-08  4.1576E-03  2.1421E-02
 "05/29/1992" "17:56:50" "PS PCM 20-30, 30-40, 40-50, <0.2,  0.2-0.3,  0.3-0.4                            "  -59.6295      12.32      7  9.0528E-02  .0000       5.2419E-02
.1732      .1111      .0000      .0000      6.4495E-02  .5343      7.5079E-03  9.4402E-03
 "05/29/1992" "17:56:54" "SC PCM 20-30, 30-40, 40-50, <0.2,  0.2-0.3,  0.3-0.4                            "  -59.0333      11.22      8   .1897      9.2764E-02  .0000
.0000      .0000      4.9612E-02  .1239      .0000      1.2642E-10  5.0996E-03  1.1890E-02
 "05/29/1992" "17:57:02" "SC PCM <5, 5-10, 10-20, >20, <0.25, >0.25                                       "  -61.4230      15.59     10   .1119       .0000       .0000
.0000      .0000      .0000      2.5766E-02  2.3627E-10  4.0282E-03  1.0973E-03
 "05/29/1992" "17:57:16" "SC PCME(SC) <5, 5-10, 10-20, >20                                                "  -60.4908      14.03     11   .2312       .0000       .0000
1.0128E-11  4.0590E-03  3.4073E-05
 "05/29/1992" "17:57:20" "FBC PCM <5, 5-10, 10-20, >20, <0.25, >0.25                                      "  -61.5539      15.72      9  7.3068E-02  .0000       .0000
3.1396E-03  .0000      4.8616E-02  .0000      6.2996E-03  4.2436E-03  1.6013E-03
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 "05/29/1992" "17:57:37" "SC PCM  5-10, 10-20, 20-30, >30                    "  -61.6197   16.18   10  9.4624E-02  .0000   1.7645E-02
4.2799E-13  4.2822E-03  2.1632E-04
 "05/29/1992" "17:57:42" "SC PCM, AR>10, 5-10, 10-20, 20-30, >30             "  -61.6197   16.18   10  9.4624E-02  .0000   1.7645E-02
4.2799E-13  4.2822E-03  2.1632E-04
 "05/29/1992" "17:57:46" "SC PCM, AR>10, 5-10, 10-20, >20, <0.25, > 0.25     "  -61.4230   15.59   10   .1119      .0000    .0000
.0000      2.5766E-02  1.9480E-11  4.0282E-03  1.0973E-03
 "05/29/1992" "17:57:54" "SC PCM, 10-20, >20, <0.1,  0.1-0.2,  0.2-0.5,  >0.5 "  -60.8243   15.06    9  8.9374E-02  .6025    .0000
.0000      3.9377E-02   .3581       .0000     -2.6301E-10  3.7544E-03  1.9807E-03
```

MLE ChiSquare DF P-Value Coefficients?

Equation?

"06/04/1992" "15:59:53" "PS M <5, 5-10, 10-20, 20-30, 30-40, 40-50, 50-60, >60 " -325.410 72.32 12 .0000 2.5437E-04 .0000
.0000 .0000 .3350 .0000 .6647 3.3093E-02 2.7314E-02
"06/04/1992" "16:00:06" "PS M <5, 5-10, 10-20, 20-30, 30-40, 40-50, 50-60, >60 (without) " -289.768 40.91 10 .0000 1.2826E-04 .0000
.0000 .0000 .3131 .0000 .6868 2.3751E-02 3.0330E-02
"06/04/1992" "16:00:34" "PS PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, 50-60, >60 " -279.861 24.45 9 2.8979E-03 .0000 .0000
1.0642E-02 .0000 .1925 .0000 .3962 2.6431E-02 1.3497E-02
"06/04/1992" "16:09:39" "SC M <5, 5-10, 10-20, 20-30, 30-40, 40-50, 50-60, >60 " -324.088 69.36 12 .0000 1.2222E-04 .0000
.0000 .0000 .4181 .0000 .5818 3.3111E-02 3.1739E-02
"06/04/1992" "16:09:53" "SC M <5, 5-10, 10-20, 20-30, 30-40, 40-50, 50-60, >60 (without) " -288.190 37.50 9 .0000 2.5206E-05 .0000
1.8243E-03 .0000 .3599 .0000 .6382 2.3345E-02 3.4731E-02
"06/04/1992" "16:10:22" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, 50-60, >60 " -279.958 24.27 9 3.1396E-03 .0000 .0000
9.7585E-03 .0000 .1659 .0000 .1266 2.5546E-02 1.7443E-02
"06/04/1992" "16:25:02" "FBC M <5, 5-10, 10-20, 20-30, 30-40, 40-50, 50-60, >60 " -327.491 76.80 12 .0000 .0000 .0000
1.1391E-02 .0000 .0000 .4578 .5308 3.2501E-02 7.0673E-02
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9.7585E-03 .0000 .1659 .0000 .6978 2.5546E-02 1.7443E-02

"06/08/1992" "14:23:24" "SC PCM, USING SUM OF AR INSTEAD OF THE SUM OF THE NUMBER OF STRUCTURES " -320.998 128.1 11 .0000 .5002 .1054
9.7772E-07
"06/08/1992" "14:23:27" "SC PCM, USING SUM OF (L^2/W) INSTEAD OF THE SUM OF THE NUMBER OF STRUCTURES " -304.439 92.38 11 .0000 .5002 4.9910E-02
3.5523E-07
"06/08/1992" "15:17:31" "SC PCM 10-20, 20-30, 30-40, 40-50, 50-60, >60, AR>100 " -282.372 31.86 9 .0000 .3233 .1434
.0000 .3697 .1637 2.7318E-02 8.6314E-02
"06/08/1992" "15:17:38" "SC PCM 10-20, 20-30, 30-40, 40-50, 50-60, >60, AR>50 " -282.195 29.24 9 .0000 2.9482E-02 .1058
.0000 .8647 1.5222E-11 2.4334E-02 2.8640E-02
"06/08/1992" "15:17:43" "SC PCM 10-20, 20-30, 30-40, 40-50, 50-60, >60, AR>30 " -284.342 33.22 9 .0000 2.5570E-02 3.1076E-02
.0000 .9434 6.3283E-14 2.5224E-02 2.2209E-02
"06/08/1992" "15:17:50" "SC PCM 10-20, 20-30, 30-40, 40-50, 50-60, >60, AR>10 " -282.527 28.52 9 2.6697E-05 1.0006E-02 .0000
7.9477E-02 .0000 -7.6669E-10 2.4802E-02 2.8345E-02
"06/08/1992" "15:18:00" "SC PCM 10-20, 20-30, 30-40, 40-50, 50-60, >60, <0.1, >0.1 " -277.397 21.06 8 6.1426E-03 .5520 5.5765E-04
6.5890E-02 .0000 .0000 4.0257E-02 .0000 .0000 .0000 .0000 .3413 2.6604E-02 3.2997E-02
"06/08/1992" "15:18:16" "SC PCM 10-20, 20-30, 30-40, 40-50, 50-60, >60, <0.2, >0.2 " -274.192 14.21 9 .1142 .0000 3.8278E-03
8.9823E-02 .0000 .9063 .0000 .0000 .0000 .0000 .0000 3.9421E-11 2.4470E-02 9.5869E-02
"06/08/1992" "15:18:33" "SC PCM 10-20, 20-30, 30-40, 40-50, 50-60, >60, <0.3, >0.3 " -273.570 13.47 9 .1417 7.5561E-03 .0000
.0000 .0000 .0000 .0000 .8731 .0000 .0000 1.6883E-02 .1024 2.5219E-02 7.8163E-02
"06/08/1992" "15:18:48" "SC PCM 10-20, 20-30, 30-40, 40-50, 50-60, >60, <0.5, >0.5 " -277.042 18.60 7 8.7967E-03 7.1726E-03 7.7336E-03

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1.8013E-02   .0000      3.6580E-02   .0000       .7005       .0000       .0000       .0000       .2300       2.3656E-02  3.0589E-02
 "06/08/1992" "15:19:15" "SC PCM 10-20, 20-30, 30-40, 40-50, 50-60, >60, <1, >1                               "  -276.804       18.60       9  2.8109E-02  1.0869E-02   .0000
.0000       .0000       .1691       .1142       .0000       .0000       .0000       .0000       .7058       2.5210E-02  1.7712E-02
 "06/08/1992" "15:19:23" "SC PCM 10-20, 20-30, 30-40, 40-50, 50-60, >60, AR>200                               "  -314.551       102.3       9   .0000       .0000       3.2936E-02
.4112       .0000      4.5280E-02   .1237       .2896

 "06/09/1992" "09:36:19" "SC PCM 10-20, 20-30, 30-40, 40-50, 50-60, >60, <0.4, >0.4                           "  -273.752       13.77       8  8.7091E-02  7.5744E-03  2.1524E-03
.0000       .0000       .0000       .0000       .9036       .0000       .0000      3.9774E-02  4.6900E-02  2.4767E-02  5.8149E-02
 "06/09/1992" "09:36:44" "SC PCM 10-20, 20-30, 30-40, 40-50, 50-60, >60, AR>20                                "  -282.130       28.46      10  6.8359E-04  2.4648E-02   .0000
.0000       .9754      5.0787E-11  2.4409E-02  2.0780E-02
 "06/09/1992" "09:36:50" "SC PCM 10-20, 20-30, 30-40, 40-50, 50-60, >60, AR>5                                 "  -280.428       24.35       9  3.0278E-03  1.0293E-02   .0000
4.9270E-02   .0000      4.6592E-02  2.4754E-02  2.5388E-02
 "06/09/1992" "09:37:02" "SC PCM 10-20, 20-30, 30-40, 40-50, 50-60, >60, AR>3                                 "  -280.621       25.34       9  1.8654E-03  9.1834E-03   .0000
.1396       .0000      9.8428E-02  2.5738E-02  1.9572E-02
 "06/09/1992" "09:51:30" "PS PCM 10-20, 20-30, 30-40, 40-50, 50-60, >60, <0.2, >0.2                           "  -273.982       14.15       8  7.7092E-02   .0000      1.7037E-03
8.9222E-02  2.5453E-04   .9088       .0000       .0000       .0000       .0000       .0000     -2.0902E-08  2.4482E-02   .2017
 "06/09/1992" "09:51:53" "FBC PCM 10-20, 20-30, 30-40, 40-50, 50-60, >60, <0.2, >0.2                          "  -276.214       18.66       8  1.5954E-02   .0000      3.9259E-03
9.9701E-02   .0000       .8806       .0000      1.5773E-02   .0000       .0000       .0000     -7.8124E-08  2.5377E-02   .1086
 "06/09/1992" "09:52:08" "PS PCM 10-20, 20-30, 30-40, 40-50, 50-60, >60, <0.3, >0.3                           "  -276.577       19.01       8  1.3996E-02   .0000      3.5134E-03
.2282      2.9401E-03   .3567       .0000       .0000       .0000       .0000       .0000       .4087       2.5828E-02  2.8763E-02
 "06/09/1992" "09:52:36" "FBC PCM 10-20, 20-30, 30-40, 40-50, 50-60, >60, <0.3, >0.3                          "  -285.851       39.03       8   .0000       .0000      1.4957E-02
.2383       .0000       .0000       .2039       .5428       .0000       .0000       .0000     -2.1203E-06  1.7593E-02  2.3597E-02
 "06/09/1992" "10:49:30" "SC PCM <5, >5, <0.1,  0.1-0.2,  0.2-0.3,  0.3-0.5,  0.5-1, 1-2, >2                  "  -306.621       96.83       9   .0000       .0000       .0000
.0000       .0000       .0000       .0000       .0000       .0000       .0000       .0000      1.0368E-02   .2379       .3233      5.4390E-02  9.2242E-04
 "06/09/1992" "10:49:54" "SC PCM <10, >10, <0.1,  0.1-0.2,  0.2-0.3,  0.3-0.5,  0.5-1, 1-2, >2               "  -288.155       44.97       9   .0000       .0000       .0000
.0000       .0000       .0000       .0000       .0000       .7228       .0000       .0000       .0000      8.3293E-02   .1248      2.6367E-02  9.8343E-03
 "06/09/1992" "10:50:29" "SC PCM <20, >20, <0.1,  0.1-0.2,  0.2-0.3,  0.3-0.5,  0.5-1, 1-2, >2               "  -277.141       18.94       9  2.4998E-02   .0000       .0000
.0000       .0000       .0000       .0000       .0000       .3188       .5973       .0000      4.5484E-02   .0000      3.8390E-02  2.2548E-02  4.7097E-02
 "06/09/1992" "10:42:08" "SC PCM <30, >30, <0.1,  0.1-0.2,  0.2-0.3,  0.3-0.5,  0.5-1, 1-2, >2               "  -278.516       21.96       8  4.1566E-03   .0000       .0000
1.3378E-04   .0000       .0000       .0000       .0000       .0000       .4087       .4290      5.4099E-02   .0000       .1080      2.6150E-02  5.0063E-02
 "06/09/1992" "10:43:04" "SC PCM <40, >40, <0.1,  0.1-0.2,  0.2-0.3,  0.3-0.5,  0.5-1, 1-2, >2               "  -274.113       13.89       9   .1256      1.4143E-04   .0000
.0000       .0000       .0000       .0000      2.8445E-04   .0000       .0000       .9300       .0000       .0000      6.9566E-02  2.6644E-02  9.1119E-02
 "06/09/1992" "10:43:44" "SC PCM <50, >50, <0.1,  0.1-0.2,  0.2-0.3,  0.3-0.5,  0.5-1, 1-2, >2               "  -285.544       42.63      10   .0000       .0000       .0000
.0000       .0000      5.0791E-04   .0000       .0000       .0000       .0000       .9601       .0000       .0000      3.9410E-02  3.3774E-02   .1998

 "06/10/1992" "09:42:52" "SC PCM(different order)<40, >40, <0.1, 0.1-0.2, 0.2-0.3, 0.3-0.5, 0.5-1, 1-2, >2"  -274.113       13.89       9   .1256      1.4143E-04   .0000
.0000       .0000       .0000       .0000      2.8445E-04   .0000       .0000       .9300       .0000       .0000      6.9566E-02  2.6644E-02  9.1119E-02
 "06/10/1992" "10:46:34" "SC M 10-20, 20-30, 30-40, >40, AR<100, 100<AR<200, AR>200                           "  -301.303       21.78      10  1.5441E-02   .0000      9.9225E-02
.0000       .0000      3.6258E-03   .0000       .0000       .0000       .7186      2.4978E-03   .1761      2.6786E-02   .6618
 "06/10/1992" "10:47:09" "SC M 10-20, 20-30, 30-40, >40, AR<100, 100<AR<200, AR>200 (without)                 "  -271.722       9.472       8   .3034       .0000      7.9714E-02
.0000       .0000      9.5295E-03   .0000       .0000       .0000       .7246      4.7535E-03   .1814      2.3813E-02   .6408
 "06/10/1992" "10:47:42" "SC PCM 30-40, 40-50, <0.2,  0.2-0.3                                                 "  -328.264       132.1      10   .0000       .4994       .0000
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.3992 .1441 .1207
"06/10/1992" "10:47:44" "SC PCM 30-40, >40, <0.2, 0.2-0.3 " -328.362 132.3 10 .0000 .4486 .0000
.4357 .1441 .1141
"06/10/1992" "10:47:46" "SC PCM 30-40 AND <0.2, 40-50 AND 0.2-0.3 " -328.264 132.1 11 .0000 .4443 .1441
.1084
"06/10/1992" "10:47:47" "SC PCM 30-40 AND <0.2, >40 AND 0.2-0.3 " -328.362 132.3 11 .0000 .4927 .1441
.1009
"06/10/1992" "10:47:49" "SC PCM <40, >40, 0.2-0.3 " -277.294 19.14 11 5.7976E-02 .9997 2.7463E-02
.1226
"06/10/1992" "10:47:55" "SC PCM <40, >40, <0.1, 0.1-0.2, 0.2-0.3, 0.3-0.4, 0.4-0.6, 0.6-1, >1 " -274.426 14.08 7 4.9035E-02 5.2545E-05 .0000
1.7299E-04 .0000 .0000 .0000 1.6964E-04 .0000 .0000 .7574 .2283 .0000 1.3866E-02 2.6012E-02 .1065
"06/10/1992" "15:23:45" "SC PCM <40, >40, <0.3, >2 " -274.857 14.75 9 9.7473E-02 5.4764E-05 2.5762E-04
4.5248E-02 2.5944E-02 9.8491E-02
"06/10/1992" "15:24:05" "SC PCM <40, >40, <0.4, >2 " -275.922 17.20 9 4.4919E-02 1.0871E-04 1.0373E-03
5.9914E-02 2.7518E-02 4.8515E-02
"06/10/1992" "15:24:25" "SC PCM <40, >40, <0.3, >3 " -274.995 14.95 9 9.1591E-02 5.9029E-05 3.1457E-03
6.6660E-02 2.5536E-02 9.0266E-02
"06/10/1992" "15:24:36" "SC PCM <40, >40, <0.3, >5 " -274.006 13.41 9 .1442 7.1369E-05 4.9037E-03
.1224 2.6666E-02 8.0706E-02
"06/10/1992" "15:24:48" "SC PCM <40, >40, <0.3, >10 " -274.370 14.68 9 9.9294E-02 7.5858E-05 1.2275E-02
.1842 2.9171E-02 8.2945E-02
"06/10/1992" "15:25:11" "SC PCM 20-40, >40, <0.3, >2 " -283.427 31.70 9 .0000 3.7466E-02 9.1336E-02
-1.5012E-12 2.5325E-02 8.2712E-02
"06/10/1992" "15:25:17" "SC PCM 20-40, >40, <0.4, >2 " -276.234 17.96 9 3.4871E-02 9.9336E-02 7.5388E-02
1.7035E-02 2.4296E-02 3.6304E-02
"06/10/1992" "15:25:24" "SC PCM 20-35, >35, <0.3, >2 " -282.898 30.25 10 .0000 .1302 .0000
.2507 2.6694E-02 2.8991E-02
"06/10/1992" "15:25:27" "SC PCM 20-45, >45, <0.3, >2 " -286.727 36.13 9 .0000 2.3230E-02 3.3283E-02
-7.5830E-12 2.4133E-02 .2121
"06/10/1992" "15:25:34" "SC PCM <20, 20-40, >40, <0.3, >2 " -274.850 14.73 9 9.7945E-02 5.4613E-05 2.7873E-04
.0000 .0000 4.5312E-02 2.5936E-02 9.8583E-02

"06/11/1992" "15:31:51" "SC PCM <40, >40 " -289.830 50.85 11 .0000 .9995 4.0751E-02
5.9240E-03
"06/11/1992" "15:31:56" "SC PCM <20 20-40, >40, <0.3, >5 " -273.833 13.04 8 .1098 7.4307E-05 .0000
1.0718E-02 2.5619E-02 .1163 2.5487E-02 7.6466E-02
"06/11/1992" "15:32:29" "SC PCM <10 10-40, >40, <0.3, >2 " -274.688 14.64 9 .1005 4.4249E-05 .0000
2.4070E-03 .0000 4.5564E-02 2.5144E-02 9.3422E-02
"06/11/1992" "15:32:48" "SC PCM <10 10-40, >40, <0.3, >5 " -273.349 12.40 8 .1337 4.5873E-05 .0000
5.1824E-03 5.4184E-03 .1346 2.4875E-02 7.0329E-02
"06/11/1992" "15:33:31" "SC PCM <20 20-40, >40, with AR>100 or w>5 " -279.057 23.32 10 8.7947E-03 .1284 .4497
2.4093E-02 1.6167E-02

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 "06/11/1992" "15:33:37" "SC PCM <20 20-40, >40, with AR>200 or w>5                               "  -287.783       57.24      10  .0000       4.7695E-02   .6415
5.4238E-02  2.0059E-02
 "06/11/1992" "16:05:03" "SC M <10, 10-20, 20-30, 30-40,.40-50, 50-60, >60, <0.4, >0.4           "  -279.728       23.25       8  2.2192E-03  3.6878E-05   .0000
.0000      .0000      .0000      .0000      2.0091E-02  .0000      .3376      .0000      .6323      .0000     9.9335E-03  2.1964E-02  .3872
 "06/11/1992" "16:06:22" "SC M <20, >20, <0.2,  0.2-0.3,  0.3-0.4,  0.4-2, 2-5, 5-8, >8 (without) "  -290.051       43.31       9  .0000       1.0731E-04   .0000
.0000      .0000      .0000      .0000      .0000      .0000      .0000      .4395      1.5005E-02  .0000     .5454      2.3980E-02  3.3505E-02
 "06/11/1992" "16:06:57" "SC M <30, >30, <0.2,  0.2-0.3,  0.3-0.4,  0.4-2, 2-5, 5-8, >8 (without) "  -278.334       19.29       7  6.5724E-03  5.7529E-05   .0000
.0000      .0000      .0000      .0000      .0000      .8490      .0000      9.9544E-02  .0000     1.6664E-04  9.9650E-04  2.1948E-02  .3498
 "06/11/1992" "16:08:07" "SC M <40, >40, <0.2,  0.2-0.3,  0.3-0.4,  0.4-2, 2-5, 5-8, >8 (without) "  -277.968       19.74       9  1.8859E-02  8.5360E-05   .0000
.0000      .0000      .0000      .0000      .0000      .0000      .5169      .4323      .0000      .0000     5.0666E-02  2.2914E-02  .2941
 "06/11/1992" "16:08:44" "SC M <10, 10-20, 20-30, 30-40, 40-50, 50-60, >60, <0.2, >0.2           "  -280.135       24.37       8  1.1420E-03  5.8051E-06   .0000
1.4206E-02  .0000      .0000      .0000      .9699      1.3334E-02  .0000      .0000      .0000      .0000     2.5917E-03  2.1348E-02  .3422
 "06/11/1992" "16:09:50" "SC M <10, 10-20, 20-30, 30-40, 40-50, 50-60, >60, <0.3, >0.3           "  -298.689       63.37       8  .0000       .0000        .0000
4.3934E-02  .0000      .0000      .0000      .4960      9.9726E-02  5.7563E-02  .0000      .0000      .0000     .3028      4.6309E-02  3.6312E-02

 "06/12/1992" "12:45:29" "SC PCM, USING SUM OF (AR)^1.8 INSTEAD OF THE SUM OF THE NUMBER OF STRUCTURES  "  -316.759   120.5   11  .0000   .5002   8.6106E-02
1.0976E-07
 "06/12/1992" "12:46:51" "SC PCM   MIMICS RJ LEE                                                  "  -314.904       103.8      11  .0000       .4998        .1020
2.5583E-08
 "06/12/1992" "14:25:51" "SC PCM <10, 10-20, 20-30, 30-40, 40-50, 50-60, >60 and ,0.2, >0.2      "  -274.192       14.22       8  7.5497E-02  .0000        .0000
.0000      3.7448E-03  8.7979E-02  .0000      .8868      .0000      2.1443E-02  .0000      .0000      .0000     -4.0984E-06  2.4473E-02  9.7935E-02
 "06/12/1992" "14:26:39" "SC PCM <10, 10-20, 20-30, 30-40, 40-50, 50-60, >60 and ,0.3, >0.3      "  -273.570       13.47       9  .1417       .0000        .0000
7.5561E-03  .0000      .0000      .0000      .0000      .0000      .8731      .0000      .0000      1.6883E-02  .1024      2.5219E-02  7.8163E-02
 "06/12/1992" "14:27:33" "SC PCM <10, 10-20, 20-30, 30-40, 40-50, 50-60, >60 and ,0.4, >0.4      "  -273.752       13.77       8  8.7091E-02  .0000        .0000
7.5744E-03  2.1524E-03  .0000      .0000      .0000      .0000      .9036      .0000      .0000      3.9774E-02  4.6900E-02  2.4767E-02  5.8149E-02
 "06/12/1992" "14:28:40" "SC PCM <20, >20 and <0.2,  0.2-0.3,  0.3-0.4,  0.4-2, 2-5, 5-8, >8    "  -273.104       12.30       8  .1378       .0000        .0000
.0000      .0000      2.8541E-03  .0000      .0000      .3170      8.8019E-03  .2178      .0000      .0000     .4536      2.4370E-02  2.3120E-02
 "06/12/1992" "14:30:01" "SC PCM <30, >30 and <0.2,  0.2-0.3,  0.3-0.4,  0.4-2, 2-5, 5-8, >8    "  -274.535       15.28       8  5.3177E-02  .0000        .0000
.0000      .0000      3.1038E-03  8.3599E-02  .0000      .0000      1.5371E-02  .5256      .0000      .0000     .3723      2.5364E-02  3.0722E-02
 "06/12/1992" "14:31:34" "SC PCM <40, >40 and <0.2,  0.2-0.3,  0.3-0.4,  0.4-2, 2-5, 5-8, >8    "  -318.182       153.4      10  .0000       .0000        .0000
3.9080E-02  3.7648E-02  .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000     .9233      3.8196E-02  1.0287E-03
 "06/12/1992" "14:32:09" "SC PCM <50, >50 and <0.2,  0.2-0.3,  0.3-0.4,  0.4-2, 2-5, 5-8, >8    "  -282.887       38.07       9  .0000       .0000        .0000
5.5882E-04  3.2760E-04  .0000      .0000      .0000      .0000      .0000      .7592      .0000      .0000     .2399      3.7498E-02  6.3278E-02
 "06/12/1992" "14:33:06" "SC PCM <5, 5-40, >40 and <0.3, >5                                     "  -272.935       12.19      10  .2716       .0000        .0000
1.7176E-03  .0000      .1453      2.5612E-02  7.0424E-02
 "06/12/1992" "14:33:22" "SC PCM <5, 5-40, >40 and <0.4, >5                                     "  -301.510       78.09       9  .0000       .0000        .0000
2.6148E-02  2.3396E-02  6.1184E-02  6.3939E-02  5.3121E-03
 "06/12/1992" "14:33:37" "SC PCM <10, 10-40, >40 and <0.4, >5                                   "  -273.662       13.27       8  .1023       2.6086E-05   .0000
7.5831E-03  5.6428E-02  3.3751E-14  2.4070E-02  4.5074E-02
 "06/12/1992" "14:33:58" "SC PCM <20, 20-40, >40 and <0.4, >5                                   "  -337.543       281.4      10  .0000       2.7954E-02   .0000
.2053      .0000      .7667      3.7371E-02  3.2598E-04
 "06/12/1992" "14:34:10" "SC PCM <20, 20-40, >40 and <0.3, >8                                   "  -345.304       353.5       9  .0000       .2255        .0000
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5.5410E-02  .0000      6.1022E-02  3.8161E-02  4.0910E-05
 "06/12/1992" "14:34:49" "SC PCM <20, 20-50, >50 and <0.3, >5                                          " -277.024      18.84       8  1.4921E-02  6.7283E-05   .0000
6.0514E-02 1.3755E-02  .1895      2.4667E-02  6.5813E-02
 "06/12/1992" "14:36:04" "SC PCM <20, 20-50, >50 and <0.4, >5                                          " -349.979      404.9       9  .0000       .3496        .0000
.1835      2.0935E-02  .4459      2.9928E-02  2.6012E-05
 "06/12/1992" "14:36:54" "SC PCM <10, 10-40, >40, with AR>=50 or WIDTH>=5 (6 categories)              " -274.917      15.55       11  .1582      .0000        .0000
6.8066E-02  .0000      .9319      2.4370E-02  1.4888E-02
 "06/12/1992" "14:36:59" "SC PCM <10, 10-40, >40, with AR>=100 or WIDTH>=5 (6 categories)             " -275.017      15.94       10  .1006      .4137        .0000
.2309       .0000      .3555      2.5908E-02  3.4688E-02
 "06/12/1992" "14:37:04" "SC PCM <10, 10-40, >40, with AR>=200 or WIDTH>=5 (6 categories)             " -286.452      56.19       9   .0000      .0000        .0000
.3874      4.7852E-02  .2899      5.2688E-02  4.5503E-02
 "06/12/1992" "14:37:11" "SC AR>=100 OR (C and CS only) WIDTH>=5, PCM, <10, 10-40, >40                " -275.017      15.94       10  .1006      .4137        .0000
.2309       .0000      .3555      2.5908E-02  3.4688E-02
 "06/12/1992" "14:37:15" "FBC AR>=100 OR SC(C and CS only) WIDTH>=5, PCM, <10, 10-40, >40             " -275.121      16.15       10  9.4586E-02  .4119       .0000
.2258       .0000      .3623      2.5958E-02  3.4841E-02
 "06/12/1992" "14:37:21" "SC PCM <40, >40, and <0.3, >0.3                                              " -276.137      17.09       9  4.6680E-02  1.6030E-05  1.8285E-04
2.2757E-02  2.5509E-02  9.4588E-02
 "06/12/1992" "16:47:32" "SC PCM <20, 20-40, >40 and >8, <0.3                                          " -273.463      12.58       8   .1262      .0000       8.1316E-05
7.5406E-02  2.7083E-02  .7421      2.5097E-02  6.9122E-02

 "06/15/1992" "11:06:50" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and <0.2, >8               " -296.708      70.84       8   .0000      .0000        .0000
3.1957E-02  .0000      .0000      .0000      4.3341E-02  .0000      .6315      1.6485E-03  .0000      .0000      .2916      2.8411E-02  1.6238E-02
 "06/15/1992" "11:08:19" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and <0.3, >8               " -301.032      82.76       10  .0000      .0000        .0000
4.7120E-02  .0000      2.9985E-02  .0000      .0000      .0000      .0000      .0000      .0000      .0000      .9229      2.5358E-02  5.3733E-03
 "06/15/1992" "11:08:49" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and <0.4, >8               " -272.385      11.16       8   .1922      .0000        .0000
9.6472E-04  .0000      4.3486E-03  .0000      .0000      .0000      .0000      .1754      .7476      .0000      7.1640E-02  2.5317E-02  6.4120E-02
 "06/15/1992" "11:10:43" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and <0.5, >8               " -272.858      11.87       7   .1043      .0000        .0000
.0000       .0000      1.3893E-03  .0000      5.2414E-02  .0000      6.0335E-02  .3280      .0000      .3594      .1984      2.4085E-02  4.6887E-02
 "06/15/1992" "11:12:36" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and <0.6, >8               " -273.029      12.11       7  9.6208E-02  .0000        .0000
.0000       .0000      3.7626E-03  .0000      3.8885E-02  .0000      .1015      .4142      .0000      7.0023E-02  .3717      2.4532E-02  3.5003E-02
 "06/15/1992" "11:14:25" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and <0.8, >8               " -273.276      12.53       7  8.3861E-02  .0000        .0000
.0000       .0000      7.6795E-03  .0000      3.4904E-03  .0000      6.0160E-02  .3190      .0000      .2732      .3365      2.4465E-02  3.7891E-02
 "06/15/1992" "11:16:10" "SC PCM <3, 3-10, 10-20, 20-30, 30-40, 40-50, >50 and <0.3, >8               " -272.209      10.93       7   .1412      .0000        .0000
3.3972E-04  .0000      4.1296E-03  .0000      .0000      .0000      .0000      4.2215E-02  .4837      .0000      .1544      2.5667E-02  9.9115E-02
 "06/15/1992" "11:18:03" "SC PCM <5, 5-8, 8-20, 20-30, 30-40, 40-50, >50 and <0.3, >8                 " -272.224      11.04       6  8.6318E-02  .0000       6.2016E-07
3.2317E-04  .0000      2.2255E-03  .0000      .0000      .0000      .0000      6.5672E-02  .3431      .0000      8.4681E-02  2.5656E-02  .1429
 "06/15/1992" "12:16:10" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 with AR>=200 or W>=8 (14 cat.) " -285.792  53.75       4   .0000      8.7093E-02  8.7093E-02
8.7093E-02  .0000      8.7093E-02  .0000      .1419      .0000      .0000      .2037      8.7093E-02  .0000      .1092      5.5273E-02  .1341
 "06/15/1992" "12:16:21" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 with AR>=100 or W>=8 (14 cat.) " -272.200  11.02       5  5.0335E-02  4.9881E-02  4.9881E-02
5.6553E-02  .0000      .2414      .0000      .0000      .0000      .0000      .2577      .0000      .2205      2.2922E-02  2.5260E-02  9.4228E-02
 "06/15/1992" "12:16:44" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 with AR>=50 or W>=8 (14 cat.)  " -273.057  12.26       6  5.5674E-02  .0000       1.3179E-07
.0000       .0000      1.3801E-02  .0000      3.7693E-02  .0000      5.3310E-02  .3375      .0000      .3226      .2351      2.3665E-02  4.4856E-02
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 "06/15/1992" "12:18:06" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 with AR>=30 or W>=8 (14 cat.)  "  -273.632      13.16      7 6.7616E-02  .0000       .0000
.0000      .0000      4.9098E-03  .0000      1.9981E-02  .0000      6.4082E-03  .2060      .0000      .6920     7.0740E-02  2.3745E-02  6.6264E-02
 "06/15/1992" "12:19:28" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 with AR>=20 or W>=8 (14 cat.)  "  -273.360      12.73      8  .1208      .0000       .0000
.0000      .0000      6.9703E-03  .0000      .0000      .0000      3.0064E-02  .2439      .0000      .5410     .1781      2.4490E-02  5.1541E-02
 "06/15/1992" "12:20:57" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 with AR>=10 or W>=8 (14 cat.)  "  -273.866      13.72      8 8.8611E-02  .0000       .0000
.0000      .0000      8.1095E-03  .0000      .0000      .0000      2.5890E-02  .2019      .0000      .4075     .3565      2.5024E-02  3.8497E-02
 "06/15/1992" "12:22:28" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 with AR>=5 or W>=8 (14 cat.)   "  -274.167      14.40      8 7.1042E-02  .0000       .0000
.0000      .0000      5.0759E-03  .0000      4.7770E-03  .0000      .0000      .1090      .0000      .7382     .1430      2.5059E-02  5.8887E-02
 "06/15/1992" "12:24:05" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 with AR>=3 or W>=8 (14 cat.)   "  -274.231      14.54      7 4.1630E-02  .0000       .0000
.0000      .0000      5.8288E-03  .0000      7.2078E-04  .0000      1.0573E-02  .1299      .0000      .6530     .2000      2.5215E-02  5.1238E-02
 "06/15/1992" "15:17:15" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and >8, <0.3                     "  -272.198      10.89      7  .1430      .0000       .0000
.0000      6.4848E-04  .0000      3.2479E-03  .0000      .0000      4.9158E-02  .0000      .0000      .4088     .4276      2.5808E-02  .1227

 "06/16/1992" "15:57:13" "SC PCM <5, 5-30, >30 and >8, <0.3                                                 "  -275.834      18.83     10 4.1618E-02  .0000       .0000
.0000      4.7435E-03  .5686      2.5768E-02  2.5232E-02
 "06/16/1992" "15:57:21" "SC PCM <5, 5-40, >40 and >8, <0.3                                                 "  -272.871      12.51     10  .2515      .0000       .0000
.0000      2.0072E-03  .7917      2.7267E-02  6.5788E-02
 "06/16/1992" "15:57:28" "SC PCM <8, 8-40, >40 and >8, <0.3                                                 "  -272.805      12.41      9  .1906      .0000       .0000
1.0688E-02 8.2511E-03  .7160      2.5565E-02  5.4117E-02
 "06/16/1992" "16:20:15" "SC PCM <10, 10-40, >40 and <0.3, >8                                               "  -272.895      12.21      8  .1414      1.5538E-05  .0000
1.1243E-02 5.4704E-02  .2171      2.4137E-02  5.6716E-02
 "06/16/1992" "16:20:42" "SC PCM <15, 15-40, >40 and <0.3, >8                                               "  -272.886      12.13      8  .1446      2.1089E-05  .0000
7.3058E-02 .1151       .3195      2.3806E-02  3.7739E-02
 "06/16/1992" "15:58:04" "SC PCM <10, 10-30, >30 and >8, <0.3                                               "  -274.890      15.82      9 7.0146E-02  .0000       .0000
.1135      4.1740E-02  .2284      2.3632E-02  1.8589E-02
 "06/16/1992" "15:58:14" "SC PCM <10, 10-50, >50 and >8, <0.3                                               "  -274.641      15.42      9 7.9344E-02  .0000       .0000
9.8803E-02 3.6726E-02  1.3111E-11 2.4535E-02  2.2019E-02
 "06/16/1992" "16:37:21" "SC PCM >50, 20-50, <20 and >8, <0.3                                               "  -275.523      16.03      8 4.1166E-02  .6671       .0000
.1482      .1710       1.8609E-04 2.3804E-02  2.4382E-02
 "06/16/1992" "15:58:39" "SC PCM <10, 10-40, >40 and AR>=100 or W>=8 (6 categories)                          "  -274.361      15.16      9 8.5993E-02  .2858       .0000
.2372      .1225       .3545      2.4533E-02  3.6979E-02
 "06/16/1992" "15:58:46" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and AR>=150 or W>=8 (14 cat.) "  -272.330      11.22      1 5.8425E-05  5.6473E-02  5.6473E-02
9.3549E-02 2.4707E-02  .2394      .0000      .0000      2.3420E-02  8.5612E-02  7.6892E-02  .1257      8.5612E-02  .1054      2.7771E-02  .1274
 "06/16/1992" "15:58:54" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and >8, <0.3 (with AR>=3)      "  -272.197      10.83      8  .2109      .0000       .0000
.0000      4.5497E-04  .0000      2.2876E-03  .0000      .0000      .0000      .0000      .0000      .2874     .5971      2.6318E-02  .1745
 "06/16/1992" "15:59:39" "SC PCM <10, 10-40, >40 and >8, <0.3 (with AR>=3)                                  "  -272.968      11.90      9  .2183      .0000       3.9534E-05
.0000      7.6856E-03  .7128      2.6190E-02  6.5721E-02

 "06/17/1992" "14:24:32" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and >8, <0.3 and AR>=10         "  -272.198      10.89      7  .1430      .0000       .0000
.0000      6.4848E-04  .0000      3.2479E-03  .0000      .0000      4.9158E-02  .0000      .0000      .4088     .4276      2.5808E-02  .1227
 "06/17/1992" "14:25:51" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and >8, <0.3 and AR>=3          "  -272.198      10.89      7  .1430      .0000       .0000
.0000      6.4849E-04  .0000      3.2479E-03  .0000      .0000      4.9158E-02  .0000      .0000      .4088     .4276      2.5808E-02  .1227
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 "06/17/1992" "14:28:12" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and >8, <0.3 (chrysotile)      "  -199.146      8.429       2 1.3952E-02   .0000        .0000
.0000       .0000       .2027       .0000       .0000       .0000       .3859       .2964       .0000       .0000      1.1885E-11  3.2157E-02  7.5085E-02
 "06/17/1992" "14:32:50" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and >8, <0.3 (amphiboles)      "  -100.336      1.656       1  .1976       .0000        .0000
.0000       .0000       .0000       .0000       9.3260E-02  .0000       .0000       5.5979E-02  .0000       .7515      7.0580E-11  2.3542E-02  .1025
 "06/17/1992" "14:33:09" "SC PCM <40, >40 and <0.2,  0.2-0.3,  0.3-0.4,  0.4-2, 2-5, 5-8, >8 (chrysotile) "  -199.147      8.432       3 3.7153E-02   .0000        .0000
.0000       .0000       7.7411E-03  .0000       .4238       .0000       .0000       .0000       6.5665E-02  .0000       .5028       3.2162E-02  2.7220E-02
 "06/17/1992" "14:33:41" "SC PCM <40, >40 and <0.2,  0.2-0.3,  0.3-0.4,  0.4-2, 2-5, 5-8, >8 (amphiboles) "  -100.379      1.697       3  .6374       .0000        .0000
.0000       .0000       .0000       .0000       3.1406E-02  .0000       .8748       .0000       .0000       .0000      9.3811E-02  2.3351E-02  8.8094E-02
 "06/17/1992" "14:33:51" "SC PCM <10, 10-40, >40 and <0.3, >8 (chrysotile)                                 "  -231.202      165.7       3  .0000       .1906        .0000
2.0354E-02  .2327       .5564       3.6817E-02  4.5930E-05
 "06/17/1992" "14:34:07" "SC PCM <10, 10-40, >40 and <0.3, >8 (amphiboles)                                 "  -100.344      1.655       3  .6468       .0000        .0000
.0000       3.9432E-02  8.5786E-02  2.3356E-02  8.8092E-02
 "06/17/1992" "14:34:13" "SC PCM <10, 10-40, >40 and >8, <0.4                                              "  -273.352      13.00       9  .1619       .0000        .0000
.1034       1.4351E-02  .6578       2.4091E-02  3.4458E-02
 "06/17/1992" "14:45:23" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and <0.3, >8 (with AR>=10)      "  -275.830      18.52       7 9.0747E-03   .0000        .0000
3.7724E-04  .0000       6.8825E-04  .0000       7.1379E-03  .0000       .0000       .0000       .2738       .0000      -1.0060E-10  2.5949E-02  .3142
 "06/17/1992" "15:45:33" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and >8, <0.3 (2 studies)        "  -301.025      12.62       8  .1249       .0000        .0000
.0000       1.5961E-03  .0000       4.1331E-02  .0000       .0000       .0000       .0000      -2.1416E-05  3.1086E-02  1.8208E-02
 "06/17/1992" "15:45:33" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and >8, <0.3 (2 studies)        "  -301.025      12.62       8  .1249       .0000        .0000
.0000       1.5961E-03  .0000       4.1331E-02  .0000       .0000       .0000       .0000      -2.1416E-05  2.1682E-02  2.9493E-02
 "06/17/1992" "15:45:50" "SC PCM <40, >40 and <0.2,  0.2-0.3,  0.3-0.4,  0.4-2, 2-5, 5-8, >8 (2 studies)  "  -300.792      12.06       6 5.9787E-02  2.6205E-05   .0000
.0000       .0000       7.8049E-04  .0000       4.1073E-02  .0000       .8914       .0000       4.1637E-02  3.2830E-02  .1416
 "06/17/1992" "15:45:50" "SC PCM <40, >40 and <0.2,  0.2-0.3,  0.3-0.4,  0.4-2, 2-5, 5-8, >8 (2 studies)  "  -300.792      12.06       6 5.9787E-02  2.6205E-05   .0000
.0000       .0000       7.8049E-04  .0000       4.1073E-02  .0000       .8914       .0000       4.1637E-02  2.0805E-02  8.7989E-02
 "06/17/1992" "15:47:24" "SC PCM <10, 10-40, >40 and <0.3, >8 (2 studies)                                  "  -300.139      11.32       8  .1837       .0000        .0000
.1094       3.2465E-02  8.7587E-02
 "06/17/1992" "15:47:24" "SC PCM <10, 10-40, >40 and <0.3, >8 (2 studies)                                  "  -300.139      11.32       8  .1837       .0000        .0000
.1094       2.0771E-02  6.6119E-02

 "06/22/1992" "15:33:41" "SC M(14) <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and <0.3, >8                  "  -277.733      20.96       9 1.2108E-02   .0000        .0000
9.7750E-04  .0000       .0000       .0000       .0000       .0000       .0000       .0000       .2541       .7450      1.9854E-10  2.1741E-02  .4278
 "06/22/1992" "15:35:19" "PS M(14) <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and <0.3, >8                  "  -277.324      19.37       9 2.1452E-02   .0000        .0000
3.3816E-03  .0000       .0000       .0000       1.6148E-02  .0000       .0000       .0000       .0000       .9455      3.4942E-02  2.2094E-02  .3327
 "06/22/1992" "15:36:20" "FBC M(14) <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and <0.3, >8                 "  -282.927      31.48       9  .0000       2.0191E-06  2.8155E-04
.0000       .0000       .0000       .8194       2.2740E-02  1.290
 "06/22/1992" "15:37:36" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and <0.3 and AR>=20, >8         "  -272.197      10.92       5 5.2268E-02  1.7829E-05  1.3304E-09
6.0850E-04  .0000       3.1381E-03  .0000       .0000       .0000       .0000       5.6291E-02  .3825       .0000      9.9690E-02  2.5851E-02  .1301
 "06/22/1992" "15:40:55" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and <0.3 and AR>=30, >8         "  -272.256      11.12       5 4.8301E-02  8.7621E-05  1.3116E-06
8.4954E-04  .0000       2.3397E-03  .0000       .0000       .0000       .0000       7.1845E-02  .3003       .0000      5.9915E-02  2.5516E-02  .1679
 "06/22/1992" "15:43:58" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and <0.3, >8 (chrysotile)      "  -174.591      3.392       2  .1827       .0000        .0000
.0000       .0000       .0000       .1688       .0000       .0000       .2492       .5106       .0000       .0000      7.1357E-02  3.0137E-02  9.0414E-02
 "06/22/1992" "15:46:08" "SC PCM <40, >40 and <0.2,  0.2-0.3,  0.3-0.4,  0.4-2, 2-5, 5-8, >8 (chrysotile) "  -174.591      3.395       2  .1825       .0000        .0000
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.0000 .0000 5.5468E-03 .0000 .3469 .0000 .0000 .0000 .0000 .0000 .3974 3.0140E-02 3.8470E-02
"06/22/1992" "15:55:24" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and <0.3, >8 (chrysotile) (avg)" -126.207 1.2755E-15 0 .0000 .0000 .0000
3.9108E-03 .0000 1.7452E-02 .0000 1.0756E-02 .0000 .0000 .0000 .0000 .0000 .9679 2.6668E-02 2.1269E-02
"06/22/1992" "16:30:35" "SC PCM <40, >40 and <0.2, 0.2-0.3, 0.3-0.4, 0.4-2, 2-5, 5-8, >8 (chrysotile) (avg)" -126.207 2.9177E-13 -1 .0000 .0000 2.8851E-04
.0000 .0000 1.4347E-02 .0000 .0000 .0000 .0000 .0000 .8395 .1459 -1.9596E-10 2.6668E-02 1.3955E-02
"06/22/1992" "15:49:00" "PS PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and <0.3, >8 " -272.711 12.25 8 .1395 .0000 .0000
8.6521E-03 .1246 .0000 .0000 .0000 .0000 .1227 .4444 .0000 .0000 .2996 2.5616E-02 3.4242E-02
"06/22/1992" "15:50:08" "FBC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 and <0.3, >8 " -275.871 18.62 8 1.6231E-02 .0000 3.7774E-04
7.0798E-04 7.2592E-03 .0000 .7180 2.5916E-02 .3137

"06/23/1992" "14:32:26" "SC PCM <20, >20 (chrysotile only - averaged K013) " -127.858 3.449 3 .3270 1.000 2.9297E-02
2.0218E-03
"06/23/1992" "15:20:51" "SC PCM <5,5-10,10-20,20-30,30-40,40-50,>50 with AR>=100 or W>=8 (14 CAT.)(no discharged)" -247.715 6.231 5 .2839 .1653 .1653
5.3902E-02 .0000 .2203 .0000 .0000 .0000 .0000 .2507 .0000 .0000 6.1001E-02 2.4264E-02 .1097
"06/23/1992" "15:21:06" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 with <0.3, >8 (no discharged) " -247.916 6.347 5 .2733 .0000 .0000
7.7664E-04 .0000 3.3297E-03 .0000 1.1683E-02 .0000 .0000 .1023 .3292 .0000 .1214 2.3640E-02 .1100
"06/23/1992" "15:21:59" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 with <0.4, >8 (no discharged) " -247.977 6.302 6 .3897 .0000 .0000
9.2037E-04 .0000 5.3676E-03 .0000 2.3489E-02 .0000 .0000 .2528 .5300 .0000 .1875 2.3356E-02 5.1364E-02
"06/23/1992" "15:22:39" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 with <0.5, >8 (no discharged) " -248.237 6.697 7 .4607 .0000 .0000
.0000 .0000 4.4608E-03 .0000 7.6930E-02 .0000 3.6633E-02 .4443 .0000 .0000 .4377 2.2722E-02 3.3184E-02
"06/23/1992" "15:43:52" "SC PCM <5,5-10,10-20,20-30,30-40,40-50,>50 with <0.5 and AR>=3,>8(no discharged)" -248.237 6.697 7 .4607 .0000 .0000
.0000 .0000 4.4608E-03 .0000 7.6930E-02 .0000 3.6633E-02 .4443 .0000 .0000 .4377 2.2722E-02 3.3184E-02
"06/23/1992" "15:50:53" "SC PCM <5,5-10,10-20,20-30,30-40,40-50,>50 with >8,<0.5and AR>=10(no discharged)" -248.223 6.690 6 .3499 .0000 1.0298E-04
.0000 .0000 .0000 .0000 .0000 .1014 .4356 6.4002E-03 .0000 .0000 -3.7956E-06 2.2698E-02 3.2980E-02
"06/23/1992" "15:45:06" "SC PCM <5,5-10,10-20,20-30,30-40,40-50,>50 with <0.5and AR>=20,>8(no discharged)" -248.139 6.630 8 .5767 4.1766E-04 .0000
.0000 .0000 .0000 .0000 .1019 .0000 .0000 .4509 .0000 .0000 .4468 2.2774E-02 3.3466E-02
"06/23/1992" "16:04:30" "SC PCM <20, >20 with <0.3, >8 (no discharged) " -250.437 9.979 9 .3517 3.1512E-04 .0000
.6923 2.1630E-02 1.6030E-02
"06/23/1992" "16:04:37" "SC PCM <40, >40 with <0.3, >8 (no discharged) " -251.384 12.81 8 .1178 9.4338E-05 3.9873E-03
.1952 2.8847E-02 7.4959E-02
"06/23/1992" "16:04:49" "SC PCM <40, >40 with <0.3, >5 (no discharged) " -250.175 9.585 8 .2948 7.0228E-05 1.5561E-02
.1310 2.4517E-02 7.8915E-02
"06/23/1992" "16:39:42" "SC PCM >10 (all with AR >= 3) (no WDC chrysotile or tremolite) " -220.082 16.49 9 5.6634E-02 .9283 2.5391E-02
4.4491E-03
"06/23/1992" "16:39:44" "SC PCM <10, 10-20, >20 (all with AR >= 3) (no WDC chrysotile or tremolite) " -219.772 16.07 9 6.4832E-02 .0000 3.9618E-12
2.5926E-02 3.8301E-04
"06/23/1992" "16:39:46" "PS PCM >10 (all with AR >= 3) (no WDC chrysotile or tremolite) " -220.532 17.26 9 4.4107E-02 .9300 2.5829E-02
4.6048E-03
"06/23/1992" "16:40:17" "PS PCM <10, 10-20, >20 (all with AR >= 3) (no WDC chrysotile or tremolite) " -220.468 17.36 9 4.2634E-02 .0000 .1894
2.6163E-02 4.7643E-04
"06/23/1992" "16:39:49" "SC(no C,CS,M,or MS) PCM >10 (all with AR >= 3) (no WDC chrysotile or tremolite) " -220.925 18.92 9 2.5190E-02 .6933 2.6422E-02
1.1936E-03

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 "06/23/1992" "16:39:51" "SC(no C,CS,M,or MS) PCM <10,10-20,>20 (all with AR >= 3) (no WDC or tremolite)  "  -220.428   17.89   9  3.5777E-02   .0000       5.4710E-11
2.6733E-02  4.2818E-04

 "06/24/1992" "14:59:32" "SC PCM >10 (all with AR>=3 and W>=0.2) (no tremolite or WDC chrysotile)        "  -219.932   16.02   9  6.5704E-02   .9655       2.5115E-02
1.0459E-02
 "06/24/1992" "14:59:34" "SC PCM <10,10-20,>20(all with AR>=3 and W>=0.2)(no tremolite or WDC chrysotile) "  -219.402   15.14   9  8.6504E-02   .0000       2.4662E-11
2.5513E-02  4.4249E-04
 "06/24/1992" "14:59:36" "FBC PCM >10 (all with AR>=3 and W>=0.2) (no tremolite or WDC chrysotile)       "  -220.855   18.70   9  2.7090E-02   .9594       2.6243E-02
1.0404E-02
 "06/24/1992" "14:59:38" "FBC PCM <10,10-20,>20(all with AR>=3 and W>=0.2)(no tremolite or WDC chrysotile)"  -220.072   16.90   8  3.0312E-02  1.9053E-03  1.9158E-12
2.6426E-02  4.8211E-04
 "06/24/1992" "14:59:41" "SC PCM <5, 5-40, >40, with W <0.5, >5
4.6480E-03   .0000       .8946      2.9880E-02  1.5430E-02                          "  -279.469   27.19  10  1.5875E-03   .0000       .0000
 "06/30/1992" "10:00:07" "SC PCM  5-40, >40, with W >5, <0.3
.8530      2.5612E-02  7.0424E-02                                                   "  -272.935   12.19  10   .2716      .0000      1.7176E-03
 "06/24/1992" "14:59:58" "SC PCM  5-40, >40, with W <0.5, >5
.8946      2.9880E-02  1.5430E-02                                                   "  -279.469   27.19  10  1.5875E-03  4.6480E-03   .0000
 "06/24/1992" "15:00:08" "SC PCM  5-40, >40, with W <0.3, >5 (and all structures AR>=3)
.1517      2.5388E-02  7.8347E-02                                                   "  -273.227   12.61  10   .2459     1.4845E-03   .0000
 "06/24/1992" "15:00:17" "SC PCM  5-40, >40, with W <0.3, >5 (and all structures AR>=5)
.1902      2.5505E-02  8.6887E-02                                                   "  -274.576   15.49  10   .1144     1.4548E-03   .0000
 "06/30/1992" "10:00:12" "SC PCM  5-40, >40, with W >5, <0.3 and AR>=3
.8530      2.5612E-02  7.0424E-02                                                   "  -272.935   12.19  10   .2716      .0000      1.7176E-03
 "06/30/1992" "10:00:17" "SC PCM  5-40, >40, with W >5, <0.3 and AR>=5
.8530      2.5612E-02  7.0424E-02                                                   "  -272.935   12.19  10   .2716      .0000      1.7176E-03
 "06/24/1992" "15:00:35" "SC PCM  5-40, >40, with W <0.5 and AR>=5, >5
.8946      2.9880E-02  1.5430E-02                                                   "  -279.469   27.19  10  1.5875E-03  4.6480E-03   .0000
 "06/24/1992" "15:00:46" "SC PCM  5-40, >40, with W <0.5 and AR>=10, >5
.8946      2.9880E-02  1.5430E-02                                                   "  -279.469   27.19  10  1.5875E-03  4.6480E-03   .0000
 "06/24/1992" "15:00:56" "SC PCM  5-40, >40, with W <0.5 and AR>=20, >5
.9347      2.8885E-02  1.5186E-02                                                   "  -278.500   24.89  10  4.7281E-03  6.8172E-03   .0000
 "06/24/1992" "15:01:00" "SC PCM  5-40, >40, with W <0.5 and AR>=30, >5
.9274      2.7747E-02  1.5152E-02                                                   "  -277.782   22.81  10  1.0646E-02  1.2458E-02   .0000
 "06/24/1992" "15:01:03" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50 (no discharged chrysotile)
2.3031E-02  9.2428E-02  4.8158E-02   .8364      2.4594E-02  7.7840E-03              "  -255.492   20.01   8  9.4712E-03   .0000       .0000
 "06/24/1992" "15:01:13" "SC PCM  5-40, >40, with W <0.3, >5 (and all structures AR>=3) (no discharged)
.2102      2.4254E-02  7.1338E-02                                                   "  -248.899   8.027   9   .5311     1.7527E-03   .0000
 "06/24/1992" "15:01:18" "SC PCM  5-40, >40, with W <0.5 and AR>=20, >5 (no discharged chrysotile)
.9926      2.6968E-02  1.6049E-02                                                   "  -253.154   18.13  10  5.2069E-02  7.4254E-03   .0000

 "06/25/1992" "10:28:00" "SC M(16) 5-40, >40 and <0.3, >5
5.5987E-02  2.9951E-02   .2335                                                      "  -320.420   65.65  12   .0000     1.2664E-03   .0000
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"06/25/1992" "10:28:07" "SC M(14) 5-40, >40 and <0.3, >5 " -286.209 40.07 10 .0000 1.1853E-03 .0000
7.1229E-02 2.3175E-02 .2276

"06/25/1992" "10:28:13" "SC M(16) 5-40, >40 and <0.3, >5 (no discharged chrysotile) " -294.603 56.81 11 .0000 1.6400E-03 .0000
.1014 2.6934E-02 .2021

"06/25/1992" "10:28:17" "SC M(14) 5-40, >40 and <0.3, >5 (no discharged chrysotile) " -260.648 32.11 9 .0000 1.4970E-03 .0000
.1164 2.1490E-02 .1998

"06/25/1992" "10:28:21" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, 40-50, >50, and <0.3, >5 " -272.188 10.78 7 .1480 .0000 .0000
4.2994E-04 .0000 1.7850E-03 .0000 .0000 .0000 .0000 3.3391E-02 .2812 .0000 4.0372E-02 2.5783E-02 .1943

"06/25/1992" "10:30:25" "SC PCM 5-40, >40 and 0.1-0.3, >5 " -272.938 12.17 10 .2734 1.8856E-03 .0000
.1407 2.5473E-02 7.0764E-02

"06/25/1992" "10:30:30" "SC PCM 5-40, >40 and 0.2-0.3, >5 " -272.985 12.21 10 .2706 3.4336E-03 .0000
.1429 2.5396E-02 6.8760E-02

"06/25/1992" "10:53:03" "SC PCM 5-40, >40 with >5, <0.3 and AR>=10 " -272.935 12.19 10 .2716 .0000 1.7176E-03
.8530 2.5612E-02 7.0424E-02

"06/25/1992" "10:30:41" "SC PCM 5-40, >40 with <0.3 and AR>=20, >5 " -272.902 12.14 10 .2751 1.8812E-03 .0000
.1478 2.5544E-02 6.9820E-02

"06/25/1992" "10:30:47" "SC PCM 5-40, >40 with <0.4 and AR>=5, >5 " -274.247 14.82 9 9.5423E-02 2.2016E-03 1.5835E-02
.1005 2.5652E-02 4.2275E-02

"06/25/1992" "10:30:58" "SC PCM 5-40, >40 with <0.4 and AR>=20, >5 " -274.223 14.82 9 9.5218E-02 2.8966E-03 1.3154E-02
.1296 2.5808E-02 4.0611E-02

"06/25/1992" "10:31:15" "SC PCM 5-40, >40 with <0.3 " -277.690 22.79 11 1.8207E-02 .9986 2.8284E-02
.1140

"06/25/1992" "10:31:18" "SC PCM 5-40, >40 with >5 " -299.923 81.71 11 .0000 .7287 5.5902E-02
1.5134E-02

"06/25/1992" "10:53:08" "PS PCM 5-40, >40 and <0.3, >5 " -276.320 19.51 10 3.3427E-02 2.1545E-02 2.1116E-02
.9573 2.7270E-02 1.2536E-02

"06/25/1992" "10:32:46" "FBC PCM 5-40, >40 and <0.3 (there are no fibers >5) " -277.767 22.97 11 1.7084E-02 .9986 2.8292E-02
.1139

"06/25/1992" "10:32:49" "SC PCM 5-40, >40 and <0.3, >5 (no discharged chrysotile) " -248.966 8.273 8 .4067 1.9186E-03 4.6766E-03
.1770 2.4251E-02 6.5809E-02

"06/25/1992" "10:32:56" "PS PCM 5-40, >40 and <0.3, >5 (no discharged chrysotile) " -252.063 14.90 9 9.3166E-02 1.7562E-02 5.3984E-02
.9285 2.4971E-02 1.2388E-02

"06/25/1992" "10:32:58" "FBC PCM 5-40, >40 and <0.3 (there are no fibers >5) (no discharged chrysotile) " -255.100 21.82 10 1.5245E-02 .9985 2.7767E-02
.1133

"06/25/1992" "10:33:01" "SC PCM(16) 5-40, >40 and <0.3, >5 " -309.395 49.04 12 .0000 1.7750E-03 .0000
.1332 3.9379E-02 6.9539E-02

"06/25/1992" "10:53:11" "SC PCM(16) 5-40, >40 with >5, <0.3 (no discharged chrysotile) " -285.380 45.29 11 .0000 .0000 2.1511E-03
.8193 3.7799E-02 6.2884E-02

"06/26/1992" "15:45:42" "SC PCM <5, >5 with W <0.3, >5 " -294.370 61.95 11 .0000 .0000 .0000
.9799 3.5380E-02 4.1829E-03

"06/26/1992" "15:45:47" "SC PCM <5, >5 with W <0.3 and AR>=20, >5 " -294.170 61.28 11 .0000 .0000 .0000

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.9779      3.4927E-02  4.1831E-03
 "06/26/1992" "15:45:49" "SC PCM 5-40, >40 with AR>=20, >5 (4 categories)                    "  -277.958     23.15    11  1.6070E-02  7.1418E-03   .0000
.9929      2.7947E-02  1.4448E-02
 "06/26/1992" "15:45:52" "SC PCM 5-40, >40 with <0.3,  0.3-5, >5                             "  -272.935     12.19    10   .2716      1.7176E-03   .0000
.0000       .8530       .1453      2.5612E-02  7.0424E-02
 "06/26/1992" "15:46:03" "SC PCM 5-40, >40 with <0.3, >5 (but exclude all M and MS)          "  -272.935     12.19    10   .2716      1.7176E-03   .0000
.1453      2.5612E-02  7.0424E-02
 "06/26/1992" "15:46:08" "SC PCM 5-40, >40 with <0.3, >5 (2 studies)                         "  -300.312     11.46     9   .2451       .1256      3.3596E-02
7.8526E-02
 "06/26/1992" "15:46:08" "SC PCM 5-40, >40 with <0.3, >5 (2 studies)                         "  -300.312     11.46     9   .2451       .1256      2.1933E-02
7.2764E-02
 "06/26/1992" "15:46:20" "SC PCM 5-40, >40 with <0.3, >5 (chrysostile only)                  "  -199.150     8.438     3  3.7044E-02  7.3631E-04  1.5232E-02
2.7287E-02  3.2171E-02   .1319
 "06/26/1992" "15:46:30" "SC PCM 5-40, >40 with <0.3, >5 (amphiboles only)                   "  -100.725     2.344     3   .5038      2.2569E-04   .0000
.1014      2.4772E-02  8.5164E-02
 "06/26/1992" "15:46:32" "SC PCM 5-40, >40 with <0.3 and AR>=20, >5 (2 studies)              "  -300.286     11.41     9   .2481       .1283      3.3499E-02
7.7677E-02
 "06/26/1992" "15:46:32" "SC PCM 5-40, >40 with <0.3 and AR>=20, >5 (2 studies)              "  -300.286     11.41     9   .2481       .1283      2.1909E-02
7.2156E-02
 "06/26/1992" "15:46:42" "SC PCM 5-40, >40 with <0.3 and AR>=20, >5 (chrysotile only)        "  -199.150     8.438     3  3.7048E-02  8.5321E-04  1.4942E-02
3.3975E-02  3.2170E-02   .1252
 "06/26/1992" "15:46:50" "SC PCM 5-40, >40 with <0.3 and AR>=20, >5 (amphiboles only)        "  -100.723     2.337     3   .5051      2.6046E-04   .0000
.1018      2.4718E-02  8.4964E-02
 "06/26/1992" "17:18:46" "SC PCM 5-40, >40 with >5 (C and CS only), <0.3 (FBC only) (2 studies)"  -300.289     11.34     8   .1824       .8903      3.3130E-02
8.6976E-02
 "06/26/1992" "17:18:46" "SC PCM 5-40, >40 with >5 (C and CS only), <0.3 (FBC only) (2 studies)"  -300.289     11.34     8   .1824       .8903      2.1784E-02
7.5613E-02
 "06/26/1992" "17:19:12" "SC PCM 5-40, >40 with >5 (C and CS only), <0.3 (FBC only) (chrysotile only)"  -199.150     8.438     3  3.7044E-02  1.5135E-02  7.5254E-04
.9546      3.2171E-02   .1304
 "06/26/1992" "17:19:48" "SC PCM 5-40, >40 with >5 (C and CS only), <0.3 (FBC only) (amphiboles only)"  -100.724     2.341     3   .5043       .0000      2.3382E-04
.8983      2.4743E-02  8.5096E-02
 "06/26/1992" "17:19:51" "SC PCM 5-40, >40 with >5, <0.3 (no discharged) (2 studies)         "  -276.253     7.248     7   .4031       .8852      3.1198E-02
9.5056E-02
 "06/26/1992" "17:19:51" "SC PCM 5-40, >40 with >5, <0.3 (no discharged) (2 studies)         "  -276.253     7.248     7   .4031       .8852      2.1220E-02
7.3280E-02
 "06/26/1992" "17:20:27" "SC PCM 5-40, >40 with >5, <0.3 (chrysotile only - no discharged)   "  -174.593     3.399     2   .1821      3.4305E-02  1.5901E-03
.7876      3.0145E-02  6.0929E-02
 "06/26/1992" "15:47:32" "SC PCM 5-40, >40 with <0.3 and AR>=20, >5 (no discharged) (2 studies)"  -276.253     7.262     7   .4017       .1027      3.1189E-02
9.3412E-02
 "06/26/1992" "15:47:32" "SC PCM 5-40, >40 with <0.3 and AR>=20, >5 (no discharged) (2 studies)"  -276.253     7.262     7   .4017       .1027      2.1218E-02
7.2605E-02
 "06/26/1992" "15:47:47" "SC PCM 5-40, >40 with <0.3 and AR>=20, >5 (chrysotile only - no discharged)"  -174.593     3.397     2   .1823      2.0719E-03  3.6781E-02
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.2255       3.0158E-02  5.1641E-02
 "06/26/1992" "15:48:06" "SC PCM 5-40, >40 with AR>=20, >5 (4 categories) (no discharged) (2 studies)      "  -279.340      13.11     9  .1571       .9916       3.1665E-02
1.3384E-02
 "06/26/1992" "15:48:06" "SC PCM 5-40, >40 with AR>=20, >5 (4 categories) (no discharged) (2 studies)      "  -279.340      13.11     9  .1571       .9916       2.1102E-02
1.9317E-02
 "06/26/1992" "15:48:13" "SC PCM 5-40, >40 with AR>=20, >5 (4 categories)(chrysotile only - no discharged)"  -174.600      3.396     2  .1823       1.1242E-03  .3689
2.1254E-11  3.0232E-02  1.2891E-02
 "06/26/1992" "15:48:16" "SC PCM 5-40, >40 with AR>=20, >5 (4 categories) (amphiboles only)                 "  -103.580      6.615     4  .1569       1.3691E-02  .0000
.9863       1.9872E-02  1.5860E-02
 "06/26/1992" "15:48:17" "SC PCM 5-40, >40 with AR>=3, >5 (4 categories) (amphiboles only)                  "  -105.610      10.10     4  3.7986E-02  8.0680E-03  .0000
.9919       2.0367E-02  1.3821E-02
 "06/26/1992" "15:48:19" "SC PCM 5-40, >40 with AR>=5, >5 (4 categories) (amphiboles only)                  "  -105.251      9.464     4  4.9692E-02  8.4672E-03  .0000
.9915       2.0225E-02  1.3745E-02
 "06/26/1992" "15:48:21" "SC PCM 5-40, >40 with AR>=10, >5 (4 categories) (amphiboles only)                 "  -104.569      8.284     4  8.0934E-02  9.2017E-03  .0000
.9908       2.0025E-02  1.4364E-02
 "06/26/1992" "15:48:23" "SC PCM 5-40, >40 with AR>=30, >5 (4 categories) (amphiboles only)                 "  -103.778      6.865     4  .1425       2.3034E-02  .0000
.9770       2.0138E-02  1.6260E-02
 "06/26/1992" "15:48:24" "SC PCM 5-40, >40 with AR>=50, >5 (4 categories) (amphiboles only)                 "  -103.554      6.499     4  .1641       5.9731E-02  .0000
.9403       2.0684E-02  1.7099E-02
 "06/26/1992" "15:48:26" "SC PCM <5, 5-40, >40 with <0.3, >5 (no discharged chrysotile)                     "  -248.966      8.273     8  .4067       .0000       .0000
1.9186E-03  4.6766E-03  .1770       2.4251E-02  6.5809E-02
 "06/26/1992" "15:48:36" "SC PCM 5-40, >40 with <0.3, 0.3-5, >5 (no discharged chrysotile)                  "  -248.966      8.273     8  .4067       1.9186E-03  .0000
4.6766E-03  .8164       .1770       2.4251E-02  6.5809E-02
 "06/26/1992" "18:00:06" "SC PCMQ >10 (all structures AR>=3,W>0.2) (no WDC chrysotile or tremolite)         "  -223.907      24.09     9  3.4107E-03  .9521       2.3551E-02
1.0063E-02
 "06/26/1992" "18:10:08" "SC PCMQ <10,10-20,>20 (all structures AR>=3,W>0.2) (no WDC chrysotile/tremolite)"  -221.562      19.60     8  1.1142E-02  .1793       3.3351E-13
2.3184E-02  4.3772E-04
 "06/30/1992" "10:44:26" "PS PCM, USING SUM OF SURFACE AREA INSTEAD OF THE SUM OF THE NUMBER OF STRUCTURES"  -285.826      39.16    11  .0000       .5002       2.9496E-02
1.0475E-06
 "06/30/1992" "10:44:27" "PS PCM, USING SUM OF VOLUME INSTEAD OF THE SUM OF THE NUMBER OF STRUCTURES      "  -291.704      55.77    11  .0000       .5002       4.7021E-02
1.0362E-06

 "07/01/1992" "15:49:07" "SC PCM 5-40, >50 and W >5, <0.3 (all structures AR>=20) (no discharged)         "  -253.886      19.50     9  2.0509E-02  .0000       7.6482E-04
.3941       2.7504E-02  .2366

 "07/02/1992" "11:56:05" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, >=40 and W <0.3, >=5                        "  -272.586      11.47     8  .1757       .0000       .0000
1.1629E-03  .0000       5.3055E-03  .0000       .0000       .0000       .0000       6.1057E-02  .1258   2.4594E-02  6.9386E-02
 "07/02/1992" "11:57:25" "SC PCM <5, 5-10, 10-20, 20-30, 30-40, >=40 and W <0.3, >=5 (no discharged)        "  -248.218      6.779     6  .3412       .0000       .0000
9.5393E-04  .0000       6.7145E-03  1.9149E-02  .0000       .0000       .0000       8.2033E-02  .1382   2.2930E-02  6.7034E-02
 "07/02/1992" "13:14:24" "SC PCM >=5 and W <0.3, >=5 (no discharged chrysotile)                             "  -267.012      49.63    10  .0000       .9815       3.0991E-02
5.0646E-03
 "07/02/1992" "13:14:26" "SC PCM 5-40, >=40 (no discharged chrysotile)                                      "  -261.069      31.75    10  .0000       .9907       2.8947E-02
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5.4757E-03
 "07/02/1992" "13:14:29" "SC PCM   >=5  (no discharged chrysotile)                                      "  -285.450      103.2      10  .0000        .9875       5.7855E-02
7.0975E-03
 "07/02/1992" "13:14:31" "SC PCM   5-40 and W <0.3, >=5  (no discharged chrysotile)                     "  -283.414      99.33      10  .0000        .9753       5.5205E-02
4.4280E-03
 "07/02/1992" "13:14:33" "SC PCM  5-40  (no discharged chrysotile)                                      "  -286.783      107.2      10  .0000        .9671       6.2602E-02
2.6253E-03
 "07/02/1992" "13:14:50" "SC PCM  <5, 5-40, >=40 and W <0.3, >=5 (no discharged chrysotile)             "  -248.966      8.273       8  .4067        .0000        .0000
1.9186E-03  4.6766E-03   .1770     2.4251E-02  6.5809E-02
 "07/02/1992" "13:15:02" "SC PCM  <5, 5-40, >=40  (no discharged chrysotile)                            "  -261.069      31.75      10  .0000        .0000        .9907
2.8947E-02  5.4757E-03
 "07/02/1992" "13:14:35" "SC PCM  <5, >=5 and W <0.3, >=5  (no discharged chrysotile)                   "  -267.012      49.63      10  .0000        .0000        .0000
.9815     3.0991E-02  5.0646E-03
 "07/02/1992" "13:14:39" "SC PCM   <5 and W <0.3 (there are no fibers W >= 5) (no discharged chrysotile)  "  -301.986      132.5      10  .0000        .6775        .1194
2.0883E-05
 "07/02/1992" "13:14:41" "SC PCM  <5, >=5  (no discharged chrysotile)                                   "  -285.450      103.2      11  .0000        1.000       5.7855E-02
8.8654E-05
 "07/02/1992" "13:14:43" "SC PCM  <5  (no discharged chrysotile)                                        "  -301.288      132.0      10  .0000        .6657        .1169
1.6960E-05
 "07/02/1992" "13:14:45" "SC PCM  5-40, >=40 and W >=5  (no discharged chrysotile)                      "  -267.213      60.09      10  .0000        .9371       5.1633E-02
1.6962E-02
 "07/02/1992" "13:14:46" "SC PCM  5-40, >=40 and W <0.3  (no discharged chrysotile)                     "  -260.510      33.58      10  .0000        .9982       3.3808E-02
.1069
 "07/02/1992" "14:50:19" "SC PCM <5,5-10,10-20,20-40,>=40 and <0.15,0.15-0.3,0.3-1,1-5,>=5 (no discharged)"  -248.178      6.674       6  .3515        .0000        .0000
.0000      .0000      .0000      ..0000      2.5839E-03  .0000      .0000      .0000      .1706      .0000      .0000      .0000      ..0000      2.5171E-02  .0000
.0000      .0000      6.0103E-02  .0000      .5370 .     .0000      .2046      2.2673E-02  5.5023E-02
 "07/02/1992" "15:42:07" "SC M(14) <5,5-10,10-20,20-40,>=40 and <0.15,0.15-0.3,0.3-1,1-5,>=5            "  -279.614      23.57       9  4.2818E-03   .0000        .0000
.0000      .0000      .0000      1.5838E-02  .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000
.0000      .0000      .0000    . .0000      .8857      2.5155E-02  7.3297E-02  2.1648E-02  .2244
 "07/02/1992" "15:43:31" "SC PCM <5,5-10,10-20,20-40,>=40 and <0.15,0.15-0.3,0.3-1,1-5,>=5             "  -272.616      11.60       7  .1137        .0000        .0000
.0000      .0000      .0000      .0000      1.8178E-03  .0000      .0000      .0000      3.3464E-02  .0000      .0000 .    .0000      .0000      .1020      .0000
.0000      .0000      1.7003E-02  .0000      .7188      .0000      .1269      2.4549E-02  7.7920E-02
 "07/02/1992" "16:13:33" "SC M(14) <5, 5-10, 10-20, 20-40, >=40 and >=5, 1-5, 0.3-1, 0.15-0.3, <0.15    "  -279.614      23.57       8  1.8615E-03   .0000        .0000
.0000      .0000      .0000      .0000      .0000      .0000      .0000      1.5838E-02  .0000      .0000      .0000      .0000      .0000      .0000      .0000
.0000      .0000      .0000      7.3297E-02  .0000      2.5155E-02 -1.2727E-09  2.1648E-02  .2244
 "07/02/1992" "16:30:29" "SC PCM <5, 5-10, 10-20, 20-40, >=40 and >=5, 1-5, 0.3-1, 0.15-0.3, <0.15     "  -272.616      11.60       6  7.0614E-02   .0000        .0000
.0000      .0000      .0000      .0000      .0000      .0000      1.8178E-03  .0000      .0000      .0000      .0000      .0000      3.3464E-02  1.7003E-02  .0000
.0000      .0000      .1020      .1269      .0000      .0000      -1.9608E-09  2.4549E-02  7.7920E-02
."07/02/1992" "17:20:59" "SC PCM <5, 5-10, 10-20, 20-40, >=40 and <0.3, 0.3-1, 1-5, >=5                 "  -272.680      11.64       8  .1674        .0000        .0000
.0000      .0000      1.2014E-03  .0000      .0000      .0000      5.4344E-03  .0000      .0000      .0000      .0000      .0000      .0000      1.1976E-02  .8382
.0000      .1431      2.4572E-02  6.7829E-02
 "07/02/1992" "17:18:45" "SC PCM <5, 5-10, 10-20, 20-40, >=40 and <0.3, 0.3-1, 1-5, >=5 (with CI)       "  -272.680      11.64       8  .1674        .0000        .0000
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.0000      .0000      1.2014E-03  .0000       .0000       .0000       5.4344E-03  .0000       .0000       .0000       .0000       .0000       .0000       1.1976E-02  .8382
.0000      .1431      2.4572E-02  6.7829E-02

 "07/06/1992" "09:32:37" "SC PCM  >=40 and W <0.3, >=5                                                            "  -310.173     118.6      11  .0000      .2645      9.1781E-02
5.7162E-02
 "07/06/1992" "10:57:33" "SC PCM  (no length or width categories)                                                 "  -322.668     131.4      11  .0000      .6354      .1125
1.3791E-05
 "07/06/1992" "10:57:42" "SC PCM  length >= 5                                                                     "  -309.474     107.2      11  .0000      .9691      6.3273E-02
2.5174E-03
 "07/06/1992" "11:18:57" "SC PCM  (no length or width categories)                                                 "  -322.668     131.4      11  .0000      .6354      .1125
1.3791E-05
 "07/06/1992" "11:19:00" "SC PCM  length >= 5                                                                     "  -309.474     107.2      11  .0000      .9691      6.3273E-02
2.5174E-03
 "07/06/1992" "11:33:31" "PS PCM  <5, 5-10, 10-20, 20-40, >=40 and W <0.15, 0.15-0.3, 0.3-1, 1-5, >=5            "  -273.275     12.67       7  7.9868E-02  .0000      .0000
.0000      .0000      .0000       5.4514E-03  .0000       .0000       .0000       .0000       .4190       3.9527E-02  .0000       .0000       4.3412E-02  .0000      .0000
.0000      .0000      7.3795E-02  .0000       .0000       .0000       .4188       2.3729E-02  2.3807E-02
 "07/06/1992" "13:44:41" "PS M(14)  <5, 5-10, 10-20, 20-40, >=40 and W <0.15, 0.15-0.3, 0.3-1, 1-5, >=5          "  -275.607     15.73       8  4.5597E-02  .0000      .0000
.0000      .0000      .0000       7.9976E-02  .0000       .0000       .0000       .0000       .3587       5.1851E-03  .0000       .0000       .0000       .0000      .0000
.0000      .0000      .0000       .0000       .0000       .2160       .3401       2.1931E-02  8.7607E-02
 "07/06/1992" "15:20:12" "SC PCM  <5, 5-10, 10-20, 20-40, >=40 and W <0.1, 0.1-0.3, 0.3-1, 1-5, >=5              "  -272.609     11.58       7  .1146       .0000      .0000
.0000      .0000      .0000       .0000       1.7628E-03  .0000       .0000       .0000       3.8041E-02  .0000       .0000       .0000       .0000       9.6416E-02 .0000
.0000      .0000      1.2887E-02  .0000       .7253       .0000       .1256       2.4639E-02  7.9469E-02

 "07/07/1992" "13:28:40" "SC PCM <5, 5-10, 10-20, 20-40, >=40 and Complex, >=1, 0.3-1, 0.15-0.3, <0.15           "  -274.051     14.09       6  2.7817E-02  .0000      .0000
.0000      .0000      .0000       .0000       .0000       .0000       1.2681E-03  .0000       .0000       7.6933E-03  .0000       .0000       .0000       .0000      .0000
.0000      .0000      .1038       4.4982E-02  .0000       6.8896E-03 -1.8720E-10  2.3811E-02  9.7120E-02
 "07/07/1992" "14:46:55" "PS PCM <5, 5-10, 10-20, 20-40, >=40 and Complex, >=1, 0.3-1, 0.15-0.3, <0.15           "  -294.903     61.42      10  .0000       .0000      .0000
.0000      .0000      .0000       .0000       .0000       .0000       .0000       .0000       .0000       .0000       .2615       .0000       .0000       .7385      .0000
.0000      .0000      .0000       .0000       .0000       .0000      -1.0440E-08  3.4370E-02  2.4421E-03
 "07/07/1992" "15:06:25" "PS PCM  <5, 5-10, 10-20, 20-40, >=40 and W <0.15, 0.15-0.3, 0.3-1, >=1, Complex        "  -274.044     14.95       6  1.9811E-02  .0000      .0000
.0000      .0000      .0000       .0000       .0000       .0000       .0000       .0000       .4217       .0000       .0000       .2071       2.8387E-03  2.8200E-04 .0000
.0000      .0000      1.0417E-02  .0000       .0000       .3577      -1.1622E-08  2.4136E-02  4.6418E-02
 "07/07/1992" "15:24:54" "PS PCM  5-10, 10-20, 20-40, >=40 and W <0.15, 0.15-0.3, 0.3-1, >=1, Complex            "  -275.101     17.10       6  8.0952E-03  .0000      .0000
.0000      .0000      .0000       .2655       .0000       .0000       .2317       4.4614E-04  .0000       .0000       2.5093E-02  .0000       2.7684E-02  .0000      .0000
.4496     -1.8055E-07 2.6883E-02  3.3488E-02
 "07/07/1992" "15:30:50" "PS PCM  5-10, 10-20, 20-40, >=40 and Complex, >=1, 0.3-1, 0.15-0.3, <0.15              "  -274.044     14.95       7  3.5898E-02  .0000      .0000
.0000      .0000      .0000       2.8399E-03  .2072       .0000       .0000       .4218       1.0419E-02  .0000       .0000       .0000       .0000       .0000      .0000
.3578     -7.4710E-09 2.4136E-02  4.6405E-02
 "07/07/1992" "15:50:02" "PS PCM  5-10, 10-20, 20-40, >=40 and Complex, >=1, 0.4-1, 0.2-0.4, <0.2                "  -273.078     12.73       8  .1208       .0000      .0000
.0000      .0000      .0000       3.1200E-03  5.6519E-02  .0000       .0000       .0000       .0000       .0000       .0000       .0000       .2888       .0000      .0000
.0000      1.4806E-10 2.4043E-02  .1039
 "07/07/1992" "16:31:01" "SC PCM  5-10, 10-20, 20-40, >=40 and Complex, >=1, 0.4-1, 0.2-0.4, <0.2                "  -272.998     12.43       6  5.2239E-02  .0000      .0000
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.0000      1.5795E-03  .0000       .0000       4.9393E-02  .0000       1.1903E-02  .0000       .0000       .0000       .0000       2.1272E-03  .0000       3.0210E-02  .0000
.0000      1.5002E-10  2.4148E-02  3.9445E-02
 "07/07/1992" "16:56:39" "PS PCM  5-10, 10-20, 20-40, >=40 and Complex, >=1, 0.4-1, <0.4                  "  -278.198      21.79       9  8.8203E-03  .0000       .0000
.0000      .0000       .0000       .4346       .0000       .0000       .0000       .0000       .0000       .1909       .3745       .0000      -1.0420E-06  2.2334E-02  1.3918E-02

 "07/08/1992" "08:36:46" "PS PCM <5, 5-10, 10-20, 20-40, >=40 and W <0.4, 0.4-1, >=1, Complex             "  -274.519      14.77       6  2.1279E-02  .0000       .0000
.0000      .0000       .0000       .0000       .0000       .0000       .0000       6.1242E-02  8.8340E-04  2.0129E-02  5.4116E-02  .0000       1.2797E-02  .8508
.0000     -7.3093E-07  2.5732E-02  7.1660E-02
 "07/08/1992" "08:42:38" "PS PCM  <5, 5-10, 10-20, 20-40, >=40 and Complex, >=1, 0.4-1, <0.4              "  -273.814      14.11       9  .1177       .0000       .0000
.0000      .0000       .0000       .0000       .0000       3.9837E-03  3.0906E-02  .0000       .0000       .0000       .0000       .0000       3.2175E-02  .0000
.0000      .9329       2.4067E-02  9.1268E-02
 "07/08/1992" "09:04:18" "PS PCM  >=40, 20-40, 10-20, 5-10, <5 and Complex, >=1, 0.4-1, <0.4              "  -292.314      55.42      10  .0000       .0000       .0000
.0000      .0000       .6995       .0000       .0000       .0000       .0000       .0000       .0000       .3005       .0000       .0000       .0000       .0000       .0000
.0000     -4.5399E-07  3.0207E-02  2.7264E-03
 "07/08/1992" "09:09:10" "PS PCM  >=40, 20-40, 10-20, 5-10, <5 and W <0.4, 0.4-1, >=1, Complex            "  -298.842      69.62      10  .0000       .0000       .0000
.0000      .0000       .0000       .0000       .0000       .9993       .0000       .0000       .0000       .0000       .0000       .0000       .0000       .0000       6.9620E-04
.0000     -2.5203E-07  4.4540E-02  2.2204E-03
 "07/08/1992" "09:16:06" "PS PCM <5, 5-10, 10-20, 20-40, >=40 and Complex, <0.4, 0.4-1, >=1               "  -273.814      14.11       8  7.8127E-02  .0000       .0000
.0000      .0000       .0000       .0000       .0000       3.9837E-03  .0000       .0000       3.0906E-02  .0000       3.2175E-02  .0000       .0000       .0000
.9329      2.6822E-10  2.4067E-02  9.1268E-02
 "07/08/1992" "09:24:17" "PS PCM <5, 5-10, 10-20, 20-40, >=40 and Complex, <0.4, >=1, 0.4-1               "  -292.314      55.42      10  .0000       .0000       .0000
.0000      .0000       .0000       .0000       .0000       .0000       .3006       .0000       .0000       .6994       .0000       .0000       .0000       .0000
.0000     -1.2442E-06  3.0200E-02  2.7271E-03
 "07/08/1992" "09:27:24" "PS PCM 5-10, 10-20, 20-40, >=40 and Complex, <0.4, 0.4-1, >=1                   "  -273.814      14.11       8  7.8127E-02  .0000       .0000
.0000      .0000       3.9837E-03  .0000       .0000       3.0906E-02  .0000       3.2175E-02  .0000       .0000       .0000       .9329       1.4118E-10  2.4067E-02  9.1268E-02
 "07/08/1992" "09:57:02" "PS PCM <5, 5-10, 10-20, 20-40,>=40 and W <0.4, 0.4-1, >=1(no complex structures)"  -275.298      16.34       7  2.1478E-02  .0000       1.2928E-03
.0000      .0000       .0000       .0000       .0000       .0000       4.5807E-02  1.8949E-02  3.3914E-02  .0000       .9000      -1.1481E-05  2.7020E-02  8.8065E-02
 "07/08/1992" "10:17:31" "PS PCM <5, 5-10, 10-20, 20-40,>=40 and W >=1, 0.4-1, <0.4(no complex structures)"  -275.298      16.34       8  3.6935E-02  .0000       1.2930E-03
.0000      .0000       .0000       .0000       4.5810E-02  .0000       .0000       .0000       3.3927E-02  1.8952E-02  .0000       .9000       2.6966E-02  8.8070E-02
 "07/08/1992" "13:34:26" "PS PCM <5,5-10,10-20,20-40,>=40 and >=1, 0.4-1, <0.4 and Complex with 6 lengths "  -273.774      14.04       7  4.9819E-02  .0000       .0000
.0000      .0000       .0000       .0000       3.7007E-02  .0000       .0000       .0000       .0000       3.4493E-02  .0000       .0000       .9198       .0000       2.8166E-03
5.9101E-03  .0000      5.3636E-10  2.3957E-02  8.8626E-02
 "07/08/1992" "14:44:47" "SC PCM <5,5-10,10-20,20-40,>=40 and >=1, 0.4-1, <0.4 and Complex with 6 lengths "  -311.176     143.3       10  .0000       .0000       .0000
.0000      .0000       .0000       .0000       .0000       5.4027E-05  .9999       .0000       .0000       .0000       .0000       .0000       .0000       .0000       .0000
.0000      .0000      -9.9125E-08  1.4853E-02  9.5085E-04
 "07/08/1992" "14:48:02" "SC PCM Complex with 6 lengths and <5,5-10,10-20,20-40,>=40 and >=1, 0.4-1, <0.4 "  -293.905      58.17       9  .0000       .0000       .0000
.0000      .0000       .0000       .0000       .0000       .0000       .0000       .0000       .0000       .0000       .0000       1.5413E-05  .1811       .0000       .8189
.0000      .0000      -1.8353E-07  4.1522E-02  3.4939E-03
 "07/08/1992" "14:58:17" "SC PCM <5,5-10,10-20,20-40,>=40 and <0.4, 0.4-1, >=1 and Complex with 6 lengths "  -272.749      11.85       7  .1049       .0000       .0000
.0000      6.5666E-04  .0000       .0000       6.0087E-03  .0000       5.8557E-02  2.6025E-02  .0000       .0000       .8173       .0000       .0000       .0000       .0000
.0000      .0000       9.1494E-02  2.4199E-02  3.6281E-02
 "07/08/1992" "15:13:14" "SC PCM <5,5-10,10-20,20-30,>30 for<.3 and 5-10,10-20,20-30,30-40,40-50,>50 for>5"  -274.867      15.39       8  5.1113E-02  .0000       3.3674E-03
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.0000     7.4658E-02   .4261      .0000      .0000      .0000      .2326      .2633      2.3275E-02  3.2685E-02
 "07/08/1992" "15:45:37" "SC PCM <5,5-10,10-20,20-40,>=40 and <0.3, 0.3-1, >=1 and Complex with 6 lengths "  -272.964      12.11      7  9.6267E-02   .0000      .0000
.0000     6.3774E-04   .0000      .0000      4.1770E-03   .0000      1.8608E-02   .0000      .0000      .0000      .8789      2.3299E-02   .0000      .0000      .0000
.0000     .0000      7.4421E-02  2.4148E-02  7.5365E-02

 "07/09/1992" "09:11:08" "SC PCM <5,5-10,10-20,20-40,>=40 and <0.4, 0.4-1, >=1 and C and CS with 6 lengths"  -272.749      11.85      7   .1049      .0000      .0000
.0000     6.5666E-04   .0000      .0000      6.0087E-03   .0000      5.8557E-02  2.6025E-02   .0000      .0000      .8173      .0000      .0000      .0000      .0000
.0000     .0000      9.1494E-02  2.4199E-02  3.6281E-02
 "07/09/1992" "11:30:24" "SC PCM  5-40, >=40  and  W <0.3                                              "  -277.690      22.79     11  1.8207E-02   .9986      2.8284E-02
.1140
 "07/09/1992" "11:30:28" "SC PCM  5-40, >=40  and  W >5                                                "  -299.923      81.71     11   .0000      .7287      5.5902E-02
1.5134E-02
 "07/09/1992" "11:30:29" "SC PCM  5-40  and  W <0.3, >5                                                "  -309.212      107.4     11   .0000      .9697      6.2884E-02
3.3178E-03
 "07/09/1992" "11:30:31" "SC PCM  5-40, >=40  and  W <0.3, >5  and  Length < 5 (no widths) (with 95% CI)  "  -318.153      159.1      9   .0000      8.1546E-02   .0000
.6999    -1.6245E-07  1.5694E-02  2.9785E-03
 "07/09/1992" "12:05:26" "SC PCM <8, 8-15, 15-25, 25-40, >=40   and  W <0.3, >=5                      "  -272.701      11.78      9   .2254      .0000      .0000
5.6375E-03   .0000      .0000      3.8505E-02   .0000      .0000      .1430      2.3986E-02  7.0573E-02
 "07/09/1992" "12:05:47" "SC PCM  10-20, 20-40, >=40  and  W <0.3, >=5                                "  -273.565      13.25      9   .1508      1.4457E-02   .0000
.0000     8.5144E-03   .1634      2.3902E-02  5.9924E-02
 "07/09/1992" "14:31:48" "SC PCM <5, 5-10, 10-20, 20-40, >=40 and <0.4, 0.4-1 and Complex with 6 lengths  "  -273.213      12.51      8   .1290      .0000      .0000
.0000     .0000      1.0729E-02  3.2242E-03   .0000      .0000      .8210      .0000      .0000      .0000      .0000      7.6252E-02  8.8839E-02  2.4809E-02  3.9978E-02
 "07/09/1992" "14:55:48" "SC PCM  5-40, >=40  and  W <0.3, >5 (multipy control animals/response by 10^6)  " -2.774611E+07   12.11     10   .2770      1.7130E-03   .0000
.1450     2.6668E-02  7.0300E-02
 "07/09/1992" "15:18:32" "SC PCM  5-40,>=40  and  W<0.3,>5 (2 studies) (control animals/response * 10^6)  " -5.549198E+07   12.10      9   .2074      .1240      2.6668E-02
8.1133E-02
 "07/09/1992" "15:18:32" "SC PCM  5-40,>=40  and  W<0.3,>5 (2 studies) (control animals/response * 10^6)  " -5.549198E+07   12.10      9   .2074      .1240      2.6668E-02
7.1689E-02
 "07/09/1992" "15:46:24" "SC M(16) <5, 5-10, 10-20, 20-40, >=40 and <0.15, 0.15-0.3, 0.3-1, 1-5, >=5     "  -310.198      37.43     11   .0000      .0000      .0000
.0000     .0000      .0000      1.7778E-02   .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000
.0000     .0000      .0000      .0000      .9076      1.9604E-02  5.5023E-02  2.2577E-02   .2350
 "07/09/1992" "15:47:33" "PS M(16) <5, 5-10, 10-20, 20-40, >=40 and <0.15, 0.15-0.3, 0.3-1, 1-5, >=5     "  -304.903      25.27     10  4.0203E-03   .0000      .0000
.0000     .0000      .0000      .1318      .0000      .0000      .0000      .0000      .1955      .0000      .0000      .0000      .0000      .0000      8.3400E-02
.0000     .0000      .0000      .0000      .0000      .1961      .3931      2.1022E-02  7.2003E-02
 "07/09/1992" "16:06:08" "SC PCM  Length < 5 (no widths) and 5-40, >=40  and  W <0.3, >5  (with 95% CI)   "  -272.935      12.19     10   .2716      .0000      1.7176E-03
.0000     .1453      2.5612E-02  7.0424E-02
 "07/09/1992" "17:22:46" "PS PCM(F&B)5-10,10-20,20-40,>40 and<.4,.4-1,>1  C only and CS with 6 length cat."  -272.433      11.32      6  7.8319E-02   .0000      .0000
.0000     .0000      2.1747E-03  7.1876E-02  5.3176E-02   .0000      .0000      .7673      .0000      .0000      .0000      .0000      .0000      .0000      .0000
.1045     9.8618E-04   .0000      .0000      .0000     -5.1981E-08  2.4947E-02  6.3726E-02

 "07/10/1992" "09:34:47" "SC PCM  Length < 5 (no widths) and 5-40, >=40  and  W >5, <0.3  (with 95% CI)   "  -272.935      12.19     10   .2716      .0000      .0000
1.7176E-03   .8530      2.5612E-02  7.0424E-02
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"07/10/1992" "10:28:12" "SC PCM <5,5-10,10-20,20-40,>=40 and <0.15,0.15-0.3,0.3-1,1-5,>=5 (Mesotheliomas)"  -60.6932   14.64   9  .1005   .0000   .0000
.0000  1.5443E-03  .0000  .0000  .0000  .0000  .0000  .0000  .0000  .0000  .0000  .0000  .0000  .0000  .0000
.4446  .0000  .5538  .0000  .0000  .0000  -5.0341E-08  4.6448E-03  6.0542E-04
"07/10/1992" "11:30:52" "SC PCM <5,5-10,10-20,20-40,>=40 and >=5,1-5,0.3-1,0.15-0.3,<0.15 (Mesotheliomas)"  -59.0535   12.20   9  .2015   .0000   .0000
.0000  .0000  7.4663E-05  7.7508E-02  .0000  .0000  .0000  .0000  .0000  .0000  .0000  .0000  .0000  .0000  .0000
.0000  .0000  .0000  .0000  .0000  .0000  4.2322E-10  1.4830E-03  1.1808E-02
"07/10/1992" "12:20:58" "SC PCM <5,5-10,10-20,20-40,>=40 & >=.3,.15-.3,<.15 & Complex w/6 lengths (Meso.)"  -60.6227   14.73   9  9.7866E-02  .0000   .0000
.0000  .0000  .0000  .0000  5.4696E-02  .0000  .8768  6.8520E-02  .0000  .0000  .0000  .0000  .0000  .0000  .0000
.0000  .0000  .0000  -1.9458E-08  4.3684E-03  7.3528E-04
"07/10/1992" "12:15:35" "SC PCM <5,5-10,10-20,20-40,>=40 & <.15,.15-.3,>=.3 & Complex w/6 lengths (Meso.)"  -60.6067   14.72   8  6.4088E-02  .0000   .0000
.0000  .0000  .0000  .0000  .8618  .0000  3.1225E-02  .0000  .0000  9.6821E-02  .0000  .0000  .0000  .0000  .0000
.0000  1.0111E-02  .0000  -5.4691E-08  4.2054E-03  9.5365E-04
"07/10/1992" "12:29:04" "SC PCM Complex w/6 lengths & <5,5-10,10-20,20-40,>=40 & <.15,.15-.3,>=.3 (Meso.)"  -59.3875   11.93   9  .2167   .0000   .0000
.0000  .0000  .0000  9.2717E-05  .0000  .0000  .0000  .0000  .0000  2.9416E-03  .0000  .0000  .0000  .0000
.0000  .0000  .9970  -1.6111E-06  4.7046E-03  1.0201E-02
"07/10/1992" "12:32:22" "SC PCM Complex w/6 lengths & <5,5-10,10-20,20-40,>=40 & >=.3,.15-.3,<.15 (Meso.)"  -60.7657   15.50   9  7.7300E-02  .0000   .0000
.0000  .0000  .0000  .0000  .0000  .0000  .0000  .0000  .0000  .0000  .1489  .0000  .5814  .2697  .0000
.0000  .0000  .0000  -1.5832E-08  4.6132E-03  2.6062E-04
"07/10/1992" "13:46:21" "SC PCM Complex w/6 lengths & <5,5-10,10-20,20-40,>=40 & <.15,>=.3,.15-.3 (Meso.)"  -59.3238   12.04   10  .2815   .0000   .0000
.0000  .0000  .0000  .0000  7.8080E-05  .0000  .0000  .0000  .0000  .0000  .0000  .0000  .0000  .1022  .0000
.0000  .0000  .0000  .8977  4.6447E-03  1.1447E-02
"07/10/1992" "14:23:02" "SC PCM  >= 20                                   "  -282.315   28.39   11  2.0676E-03  .2055   .7945
2.5406E-02  1.0021E-02
"07/10/1992" "15:20:11" "SC PCM  >= 20  and < 0.4                        "  -285.310   39.84   11  .0000   .4983   .5017
2.6927E-02  1.2277E-02

"07/16/1992" "09:13:25" "SC PCM <5, 5-10, 10-20, 20-40, >=40 & <0.4 and Complex only with 6 lengths    "  -273.250   12.63   7  8.0924E-02  .0000   1.5099E-04
1.0898E-02  4.2320E-03  .8006  .0000  .0000  .0000  .1114  .0000  7.2753E-02  2.4602E-02  4.1308E-02
"07/16/1992" "09:14:13" "SC PCM <5, 5-10, 10-20, 20-40, >=40 & <0.2, 0.2-0.4 and Complex only w/6 lengths"  -273.150   12.42   8  .1328   .0000   .0000
.0000  6.5172E-04  .0000  1.4206E-02  .0000  .0000  .0000  .8095  .0000  .0000  .0000  .1250  .0000  5.0575E-02  2.4376E-02
4.2294E-02
"07/16/1992" "16:17:33" "SC PCM <5, 5-10, 10-20, 20-40, >=40 & >=1, 0.4-1, <0.4 (no complex structures)  "  -273.681   13.88   7  5.2712E-02  .0000   2.4004E-04
.0000  .0000  .0000  .0000  5.0739E-02  .0000  1.1999E-02  2.7987E-02  .0000  6.2087E-04  .0000  .0000  .9084  2.4677E-02  4.0742E-02

"07/20/1992" "11:16:23" "SC PCM  Length >=20 and  Width <0.2             "  -313.069   137.2   11  .0000   .5000   .5000
7.8262E-02  8.3237E-02
"07/20/1992" "11:16:24" "SC PCM  Length >=30                             "  -287.475   40.36   11  .0000   .4976   .5024
3.6883E-02  9.8082E-03
"07/20/1992" "11:16:25" "SC PCM  Length >=30 and  Width <0.4             "  -316.358   110.2   11  .0000   .5702   .4298
.1132  2.6895E-02
"07/20/1992" "11:16:26" "SC PCM  Length >=30 and  Width <0.2             "  -331.356   132.3   11  .0000   .5175   .4825
.1544  .1622
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 "07/20/1992" "11:16:27" "SC PCM  Length >=20 and  Width >=0.4                        " -285.590   34.13   11  .0000     .3007      .6993
2.9009E-02  1.0020E-02
 "07/20/1992" "11:16:28" "SC PCM  Length >=10                                        " -292.283   56.96   11  .0000     3.6654E-02 .9633
3.0399E-02  1.0603E-02
 "07/20/1992" "16:59:38" "SC PCM  F&B with 5-40,<0.3, F&B with >=40,<0.3, and Complex only with >=40,>=5 " -272.933   12.20   10  .2712     1.7376E-03 .8516
.1467      2.5581E-02  7.0175E-02
 "07/20/1992" "17:02:26" "SC PCM  F=>40,<.3,  B=>40,<.3,  Complex=>40,>5,  F=5-40,<.3,  B=5-40,<.3   " -272.537   11.55   8   .1718     .4988      .4405
5.9873E-02  8.8266E-06  8.3673E-04  2.9366E-02  .1525

 "07/21/1992" "13:14:11" "SC PCM  5-40 & <0.3,  >=40 &<0.3,  and >=40 & >=5           " -272.935   12.19   10  .2716     1.7176E-03 .8530
.1453      2.5612E-02  7.0424E-02
 "07/21/1992" "13:19:20" "SC PCM  >=40 & >=5,  5-40 & <0.3, and >=40 &<0.3            " -272.935   12.19   10  .2716     .1453      1.7176E-03
.8530      2.5612E-02  7.0424E-02

 "08/06/1992" "15:38:36" "SC PCM  length >= 8 and width < 0.25                        " -306.530   100.2   11  .0000     .3319      .6681
5.4171E-02  4.4551E-03

 "12/14/1992" "16:30:46" "SC PCM  Length < 5 (no widths) and 5-40, >=40  and  W <0.3, >5  (with 95% CI)  " -272.935   12.19   10  .2716     .0000      1.7176E-03
.0000      .8530      .1453      2.5612E-02  7.0424E-02

 "12/15/1992" "10:16:36" "(all except chrysotile) SC PCM <5,5-10,10-20,20-40,>=40 and <0.15,0.15-0.3,0.3-1,1-5,>=5      " -100.359    1.685    3  .6399
.0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000
.0000      .0000      .0000      .0000      7.6546E-02 .0000      .9027      .0000      .0000      2.0714E-02 2.2772E-02 8.6916E-02
 "12/15/1992" "10:17:47" "(chrysotile only) SC PCM <5,5-10,10-20,20-40,>=40 and <0.15,0.15-0.3,0.3-1,1-5,>=5      " -199.146    8.430    1  2.9414E-03 1.9054E-08
.0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .1719      .0000      .0000      .0000      .0000      .0000      .0000
.0000      2.0494E-02 .0000      .5626      .0000      .0000      .2450      .0000      -6.1822E-05 3.2157E-02 3.7205E-02

 "12/17/1992" "14:09:01" "(chrysotile only) SC PCM <5,5-10,10-20,20-40,>=40 and >=5,1-5,0.3-1,0.15-0.3,<0.15      " -224.122    109.7    3  .0000      .0000
.0000      .0000      .1402      9.5597E-03 .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .8502
.0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      1.2193E-07 5.9591E-02 1.1295E-04

 "12/18/1992" "09:34:18" "(chrysotile only) SC PCM >=40,<5,5-10,10-20,20-40 and <0.15,0.15-0.3,0.3-1,1-5,>=5      " -199.146    8.430    3  3.7196E-02 .0000
.0000      .2450      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .1719      .0000
.0000      .0000      .0000      .0000      .0000      .0000      2.0501E-02 .0000      .5625      3.2158E-02 3.7206E-02

 "10/08/1993" "16:02:37" "SC PCM 5-40, >=40 with >=5, < 0.3 (All except chrysotile)   " -2.774594E+07  2.321   3   .5082     .0000      7.1027E-05
9.8000E-02  .9019      2.6668E-02  8.6399E-02

 "10/12/1993" "17:03:34" "SC PCM >=40, 5-40 with <0.3, >=5 (Chrysotile only) (d1*1000,d2*100,d4*30)  " -2.774604E+07  8.826   3   3.0963E-02 .3958   9.4552E-02
.2883      .2214      2.6668E-02  3.3475E-04

 "03/23/1994" "14:46:29" "SC - Length: <5, 5-40; Width:  <.3, >5                      " -271.156   8.005   10  0.6280    2.5270E-03 0.0000E+00
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0.9161      8.1337E-02  2.3018E-02  8.4603E-02
 "03/23/1994" "14:52:42" "SC - Length: 5-20, >20; Width:  <.3, >5                                     "  -276.444      17.53       10  6.2729E-02  1.5736E-02  0.0000E+00
0.3639      0.6204      2.1557E-02  1.0547E-02
 "03/23/1994" "15:13:12" "SC - Length: 5-40, >40; Width:  >5                                           "  -303.315      90.11       11  0.0000E+00  0.3142      0.6858
6.1680E-02  1.6153E-02
 "03/23/1994" "15:13:26" "SC - Length: 5-20, >20; Width:  <.3                                          "  -284.330      35.14       11  0.0000E+00  1.5189E-02  0.9848
2.2466E-02  1.0049E-02
 "03/23/1994" "15:35:48" "SC - Length: 5-20, >20; Width:  <.3 and Length: 5-40, >40; Width:  >5        "  -275.192      15.27       10  0.1217      1.1560E-02  0.2105
0.0000E+00  0.7780      2.2547E-02  1.5203E-02

 "06/28/1994" "15:56:48" "SC (smooth):  L: 5-10, 10-20, 20-40, >40; W: 0-.15, .15-.3, .3-1, 1-5, >5    "  -274.350      13.01        8  0.1108      0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00  9.3741E-02  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  1.7745E-02  0.0000E+00  2.8592E-02  0.0000E+00  0.0000E+00  0.5198      0.0000E+00
0.0000E+00  0.0000E+00  0.3401
  2.1446E-02  6.0462E-02

 "06/30/1994" "08:40:56" "SC (smooth): L: <5, 5-10, 10-20, 20-40, >40; W: 0-.15, .15-.3, .3-1, 1-5, >5  "  -285.085      51.34        9  0.0000E+00  2.0498E-04  7.1561E-05
0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00
  0.7434      0.0000E+00  0.0000E+00  0.0000E+00  0.2563      4.5062E-02  6.3313E-02

 "06/30/1994" "09:27:22" "SC (smooth): L: <5, 5-10, 10-20, 20-40, >40; W: 0-.15, .15-.3, .3-1, 1-5, >5  "  -272.652      10.23        9  0.3313      0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.3393      0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
2.2450E-02  0.0000E+00  0.0000E+00
  0.0000E+00  0.1061      0.0000E+00  0.0000E+00  0.5322      2.1610E-02  2.6262E-02

 "07/05/1994" "12:25:40" "SC (smooth): L: <5, 5-10, 10-20, 20-40, >40; W: 0-.15, .15-.3, .3-1, 1-5, >5  "  -274.379      14.21        8  7.5695E-02  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  8.6406E-04  0.0000E+00  0.0000E+00  0.0000E+00  9.4722E-02  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
1.8899E-02  0.0000E+00  0.0000E+00
  0.0000E+00  0.4309      0.0000E+00  0.0000E+00  0.4546      2.3140E-02  2.9659E-02

 "07/05/1994" "13:42:25" "SC (smooth) - Length: 5-40, >40; Width:  <.3, >5                             "  -273.849      12.39       10  0.2589      5.4909E-03  0.0000E+00
0.6729      0.3216      2.1457E-02  3.1507E-02
 "07/05/1994" "13:46:50" "SC (smooth) - Length: 5-40, >40; Width:  <.3, >5                             "  -274.767      14.82       10  0.1382      3.1150E-03  0.0000E+00
0.6166      0.3803      2.2734E-02  3.0645E-02

 "07/11/1994" "09:30:21" "Davis Studies - Using mass to calculate the constant for the dose            "  -271.857      9.198        7  0.2382      0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  5.9335E-02  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  7.7491E-02  0.0000E+00  0.0000E+00  0.0000E+00
0.0000E+00  0.3107      0.0000E+00
  0.0000E+00  0.0000E+00  0.5525      0.0000E+00 -7.1447E-05  2.1965E-02  2.1994E-02

 "07/11/1994" "09:48:26" "PS (smooth) L: <5, 5-10, 10-20, 20-40, >40; W: <.15, .15-.3, .3-1, 1-5, >5    "  -274.561      15.30        8  5.2770E-02  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.2206      0.0000E+00  0.0000E+00  1.5167E-03  0.1926      0.0000E+00  0.0000E+00  0.0000E+00
```

0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.5853 0.0000E+00 -2.9093E-07 2.3400E-02 1.7669E-02

"09/06/1994" "14:33:11" " SC - Length: <5, 5-10, 10-20 20-40, >40; F&B, C&M " -275.569 16.15 9 6.3160E-02 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 5.2769E-02 2.5228E-02 0.0000E+00 0.0000E+00 0.8311 9.0947E-02 2.2160E-02 1.5963E-02
"09/06/1994" "14:44:46" " PS - Length: <5, 5-10, 10-20 20-40, >40; F&B, C&M " -276.055 16.35 9 5.9294E-02 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 6.4922E-02 1.4464E-02 0.0000E+00 0.0000E+00 0.7031 0.2175 2.2220E-02 1.4475E-02

"09/08/1994" "09:59:21" "(Indirect) PS - Length: <5, 5-10, 10-20 20-40, >40; F&B, C&M " -281.736 33.23 11 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 1.9526E-02 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.9805 2.7743E-02 0.1171
"09/08/1994" "10:40:42" "(Indirect) PS - Length: <5, 5-10, 10-20 20-40, >40; F&B, C&M " -281.698 33.16 11 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 2.0334E-02 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.9797 2.7748E-02 0.1125
"09/08/1994" "10:40:54" "(Indirect) SC - Length: <5, 5-10, 10-20 20-40, >40; F&B, C&M " -301.014 90.67 9 0.0000E+00 0.0000E+00 0.0000E+00
1.1306E-03 0.6515 0.0000E+00 0.3474 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 6.7921E-02 2.4401E-02

"09/09/1994" "15:25:33" "(Indirect) SC - Length: <5, 5-10, 10-20 20-40, >40; F&B (w<.3), C&M " -301.014 90.67 9 0.0000E+00 0.0000E+00 0.0000E+00
1.1306E-03 0.6515 0.0000E+00 0.3474 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 6.7921E-02 2.4401E-02
"09/09/1994" "15:25:54" "(Indirect) PS - Length: <5, 5-10, 10-20 20-40, >40; F&B (w<.3), C&M " -281.698 33.16 11 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 2.0334E-02 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.9797 2.7748E-02 0.1125

"09/09/1994" "15:28:54" " (Direct) PS - Length: <5, 5-10, 10-20 20-40, >40; F&B (w<.3), C&M " -277.173 17.54 8 2.4088E-02 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 2.0403E-02 9.0581E-04 0.0000E+00 4.6108E-03 0.9375 3.6547E-02 2.2579E-02 0.1224
"09/09/1994" "15:29:19" " (Direct) SC - Length: <5, 5-10, 10-20 20-40, >40; F&B (w<.3), C&M " -272.162 9.944 9 0.3545 0.0000E+00 0.0000E+00
1.7669E-03 0.0000E+00 3.8221E-03 0.0000E+00 0.0000E+00 0.0000E+00 0.9790 1.5448E-02 2.2709E-02 0.1088

"09/15/1994" "15:28:41" "(Indirect) PS - Length: <5, 5-10, 10-20 20-40, >40; width: <.3, >= .3 " -282.522 33.70 10 0.0000E+00 0.0000E+00 0.0000E+00
1.6818E-04 5.2736E-02 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.9471 2.6545E-02 0.1388
"09/15/1994" "15:29:00" "(Indirect) PS - Length: <5, 5-10, 10-20 20-40, >40; F&B (w<.3), C&M (w>=.3) " -281.698 33.16 11 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 2.0334E-02 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.9797 2.7748E-02 0.1125
"09/15/1994" "15:29:18" "(Indirect) SC - Length: <5, 5-10, 10-20 20-40, >40; width: <.3, >= .3 " -312.657 116.4 9 0.0000E+00 1.1927E-04 0.0000E+00
1.3661E-03 0.0000E+00 0.0000E+00 0.9985 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 8.5000E-02 1.2810E-02
"09/15/1994" "15:29:34" "(Indirect) SC - Length: <5, 5-10, 10-20 20-40, >40; F&B (w<.3), C&M (w>=.3) " -304.851 103.5 8 0.0000E+00 2.1660E-07 0.0000E+00
8.6262E-04 0.6668 0.0000E+00 0.3324 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 8.1093E-02 2.5418E-02

"09/29/1994" "15:14:20" "(Indirect) PS - Length: <5, 5-10, 10-20 20-40, >40; width: <.3, >= 1 " -278.476 26.59 10 2.1803E-03 0.0000E+00 0.0000E+00
0.0000E+00 0.1713 0.0000E+00 0.1244 0.0000E+00 0.0000E+00 0.0000E+00 0.7044 2.8964E-02 1.1187E-02
"09/29/1994" "15:14:30" "(Indirect) PS - Length: <5, 5-10, 10-20 20-40, >40; width: <1, >= 1 " -278.476 26.59 10 2.1803E-03 0.0000E+00 0.0000E+00
0.0000E+00 0.1713 0.0000E+00 0.1244 0.0000E+00 0.0000E+00 0.0000E+00 0.7044 2.8964E-02 1.1187E-02
"09/29/1994" "15:14:38" "(Indirect) SC - Length: <5, 5-10, 10-20 20-40, >40; width: <.3, >= 1 " -273.829 15.15 8 5.5433E-02 5.3701E-05 2.6475E-03
0.0000E+00 0.0000E+00 0.0000E+00 0.9859 1.1353E-02 0.0000E+00 0.0000E+00 -6.8408E-09 2.5704E-02 1.2676E-02
"09/29/1994" "15:14:46" "(Indirect) SC - Length: <5, 5-10, 10-20 20-40, >40; width: <1, >= 1 " -273.637 14.50 8 6.8763E-02 5.1098E-05 2.3654E-03
0.0000E+00 0.0000E+00 0.0000E+00 0.9855 1.2036E-02 0.0000E+00 0.0000E+00 7.0771E-10 2.5422E-02 1.2459E-02

"10/08/1994" "13:35:28" " (Direct) PS - Length: 5-35, >35; width: <.4, >=.4	"	-273.526	12.55	9	0.1832	3.6855E-02	1.0638E-02
0.9525 -4.4052E-13 2.2537E-02 4.9013E-02							
"10/08/1994" "13:35:30" " (Direct) SC - Length: 5-35, >35; width: <.4, >=.4	"	-274.549	13.85	10	0.1792	6.7383E-03	0.0000E+00
0.9933 1.9299E-13 2.2452E-02 2.6220E-02							
"10/08/1994" "13:35:33" " (Direct) PS - Length: 10-35, >35; width: <.4, >=.4	"	-278.769	21.65	9	9.3099E-03	0.3404	4.9499E-02
0.3818 0.2283 2.4778E-02 1.6989E-02							
"10/08/1994" "13:35:35" " (Direct) SC - Length: 10-35, >35; width: <.4, >=.4	"	-274.577	13.29	9	0.1492	2.7992E-02	1.8079E-02
0.9539 1.1028E-13 2.1312E-02 2.0133E-02							
"10/08/1994" "13:35:38" " (Direct) PS - Length: 10-30, >30; width: <.4, >=.4	"	-278.770	21.61	9	9.4643E-03	0.1124	5.9273E-02
0.7112 0.1171 2.2471E-02 2.1357E-02							
"10/08/1994" "13:35:41" " (Direct) SC - Length: 10-30, >30; width: <.4, >=.4	"	-275.485	15.94	9	6.7477E-02	3.2623E-02	2.3444E-02
0.9238 2.0145E-02 2.1867E-02 1.4365E-02							
"10/08/1994" "13:35:43" " (Direct) PS - Length: 5-30, >30; width: <.4, >=.4	"	-273.993	12.89	9	0.1669	1.9502E-02	2.1946E-02
0.9586 -2.2348E-10 2.0451E-02 3.4136E-02							
"10/08/1994" "13:35:46" " (Direct) SC - Length: 5-30, >30; width: <.4, >=.4	"	-277.242	19.78	10	3.0632E-02	8.8853E-03	0.0000E+00
0.9062 8.4893E-02 2.3156E-02 1.5083E-02							
"10/08/1994" "13:35:48" " (Direct) PS - Length: >40; width: <.4, >=.4	"	-331.352	132.3	11	0.0000E+00	1.000	3.8068E-14
0.1544 0.1680							
"10/08/1994" "13:35:51" " (Direct) SC - Length: >40; width: <.4, >=.4	"	-300.376	70.55	11	0.0000E+00	0.7468	0.2532
5.6862E-02 3.1167E-02							
"10/08/1994" "15:07:24" " (Direct) PS - Length: 5-35, >35; width: <.4, >=.4	"	-273.526	12.55	9	0.1832	3.6855E-02	1.0638E-02
0.9525 -4.4052E-13 2.2537E-02 4.9013E-02							
"10/08/1994" "15:07:27" " (Direct) SC - Length: 5-35, >35; width: <.4, >=.4	"	-274.549	13.85	10	0.1792	6.7383E-03	0.0000E+00
0.9933 1.9299E-13 2.2452E-02 2.6220E-02							
"10/08/1994" "15:07:29" " (Direct) PS - Length: 10-35, >35; width: <.4, >=.4	"	-278.769	21.65	9	9.3099E-03	0.3404	4.9499E-02
0.3818 0.2283 2.4778E-02 1.6989E-02							
"10/08/1994" "15:07:32" " (Direct) SC - Length: 10-35, >35; width: <.4, >=.4	"	-274.577	13.29	9	0.1492	2.7992E-02	1.8079E-02
0.9539 1.1028E-13 2.1312E-02 2.0133E-02							
"10/08/1994" "15:07:35" " (Direct) PS - Length: 10-30, >30; width: <.4, >=.4	"	-278.770	21.61	9	9.4643E-03	0.1124	5.9273E-02
0.7112 0.1171 2.2471E-02 2.1357E-02							
"10/08/1994" "15:07:38" " (Direct) SC - Length: 10-30, >30; width: <.4, >=.4	"	-275.485	15.94	9	6.7477E-02	3.2623E-02	2.3444E-02
0.9238 2.0145E-02 2.1867E-02 1.4365E-02							
"10/08/1994" "15:07:41" " (Direct) PS - Length: 5-30, >30; width: <.4, >=.4	"	-273.993	12.89	9	0.1669	1.9502E-02	2.1946E-02
0.9586 -2.2348E-10 2.0451E-02 3.4136E-02							
"10/08/1994" "15:07:44" " (Direct) SC - Length: 5-30, >30; width: <.4, >=.4	"	-277.242	19.78	10	3.0632E-02	8.8853E-03	0.0000E+00
0.9062 8.4893E-02 2.3156E-02 1.5083E-02							
"10/08/1994" "15:07:47" " (Direct) PS - Length: >40; width: <.4, >=.4	"	-331.352	132.3	11	0.0000E+00	1.000	3.8068E-14
0.1544 0.1680							
"10/08/1994" "15:07:49" " (Direct) SC - Length: >40; width: <.4, >=.4	"	-300.376	70.55	11	0.0000E+00	0.7468	0.2532
5.6862E-02 3.1167E-02							
"10/10/1994" "08:00:28" " (Direct) PS - Length: 5-35, >35; width: <.4, >=.4	"	-273.526	12.55	9	0.1832	3.6855E-02	1.0638E-02

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0.9525      1.1095E-13  2.2538E-02  4.9012E-02
 "10/10/1994" "08:00:31" " (Direct) SC - Length: 5-35, >35; width: <.4, >=.4          " -274.549    13.85    10  0.1793      6.7384E-03  0.0000E+00
0.9933      1.9284E-13  2.2454E-02  2.6220E-02
 "10/10/1994" "08:00:33" " (Direct) PS - Length: 10-35, >35; width: <.4, >=.4         " -278.768    21.65     9  9.3202E-03  0.3404      4.9500E-02
0.3817      0.2283      2.4778E-02  1.6987E-02
 "10/10/1994" "08:00:36" " (Direct) SC - Length: 10-35, >35; width: <.4, >=.4         " -274.577    13.29     9  0.1493      2.7991E-02  1.8080E-02
0.9539      1.0979E-13  2.1314E-02  2.0134E-02
 "10/10/1994" "08:00:38" " (Direct) PS - Length: 10-30, >30; width: <.4, >=.4         " -278.771    21.61     9  9.4607E-03  0.1123      5.9294E-02
0.7113      0.1171      2.2472E-02  2.1356E-02
 "10/10/1994" "08:00:41" " (Direct) SC - Length: 10-30, >30; width: <.4, >=.4         " -275.485    15.94     9  6.7504E-02  3.2620E-02  2.3446E-02
0.9238      2.0172E-02  2.1869E-02  1.4365E-02
 "10/10/1994" "08:00:44" " (Direct) PS - Length: 5-30, >30; width: <.4, >=.4          " -273.992    12.89     9  0.1670      1.9478E-02  2.1954E-02
0.9586      2.7876E-13  2.0451E-02  3.4131E-02
 "10/10/1994" "08:00:47" " (Direct) SC - Length: 5-30, >30; width: <.4, >=.4          " -277.241    19.77    10  3.0658E-02  8.8850E-03  0.0000E+00
0.9062      8.4873E-02  2.3157E-02  1.5084E-02
 "10/10/1994" "08:00:49" " (Direct) PS - Length: >40; width: <.4, >=.4                " -331.357    132.3    11  0.0000E+00   1.000      3.8065E-14
0.1544      0.1680
 "10/10/1994" "08:00:52" " (Direct) SC - Length: >40; width: <.4, >=.4                " -300.376    70.55    11  0.0000E+00  0.7468      0.2532
5.6857E-02  3.1165E-02
 "10/18/1994" "10:52:04" " (Direct) SC - Length: 5-40, >40; width: <.4, >=.4 (not adjusted)  " -275.345    17.84    10  5.6943E-02  2.4333E-03  0.0000E+00
0.9963      1.2560E-03  2.7391E-02  4.7399E-02
 "10/18/1994" "10:52:22" " (Direct) SC - Length: 5-40, >40; width: <.3, >=.3 (not adjusted)  " -275.510    17.22    10  6.8761E-02  1.3829E-03  0.0000E+00
0.9684      3.0243E-02  2.5583E-02  8.5973E-02
 "11/10/1994" "13:06:25" " (Direct) SC - L: 5, W: <.4; L:5, W: >=.4; L: >40, w: <.4 (not adjusted)  " -275.346    17.86    11  8.4167E-02  2.4379E-03  0.0000E+00
0.9976      2.7465E-02  4.7575E-02

                                                                                        Log-Like    Chi-S    DF  p-value     coefficients for each
length-width category followed by 2 equation coefficients
 "10/22/1996" "19:32:55" "PS PCM  lengths <10, >=10                                   " -296.320    69.01    12  0.0000E+00  0.0000E+00   1.000
3.4161e-02  3.5653e-04
 "10/22/1996" "19:32:56" "PS PCM  lengths >=10                                        " -296.320    69.01    12  0.0000E+00   1.000      3.4161e-02
3.5653e-04
 "10/22/1996" "19:32:56" "PS PCM  lengths >=10 and widths < 0.3                       " -325.595    129.6    12  0.0000E+00   1.000      0.1064
2.6484e-03
 "10/22/1996" "19:32:56" "PS PCM  lengths >=10 and widths < 0.4                       " -312.334    110.2    12  0.0000E+00   1.000      6.6970e-02
1.9852e-03
 "10/22/1996" "19:32:57" "PS PCM  lengths >=10 and widths < 0.5                       " -306.968    96.93    12  0.0000E+00   1.000      5.5436e-02
1.4187e-03
 "10/22/1996" "19:32:57" "PS PCM  lengths >=10 and widths >=0.3                       " -297.031    70.29    12  0.0000E+00   1.000      3.5080e-02
3.8243e-04
 "10/22/1996" "19:32:57" "PS PCM  lengths >=10 and widths >=0.4                       " -298.067    72.82    12  0.0000E+00   1.000      3.6791e-02
4.0886e-04
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"10/22/1996" "19:32:57" "PS PCM  lengths >=10 and widths >=0.5                    " -298.522   73.82   12 0.0000E+00  1.000      3.7227e-02
4.4693e-04
"10/22/1996" "19:32:58" "PS PCM  lengths <10, >=10 and widths <0.3, >=0.3      " -296.228   68.97   11 0.0000E+00 0.0000E+00 0.0000E+00
0.6171     0.3829     3.4084e-02  8.9173e-04
"10/22/1996" "19:32:58" "PS PCM  lengths <10, >=10 and widths <0.4, >=0.4      " -296.124   68.75   11 0.0000E+00 0.0000E+00 0.0000E+00
0.6218     0.3782     3.3966e-02  8.6454e-04
"10/22/1996" "19:32:58" "PS PCM  lengths <10, >=10 and widths <0.5, >=0.5      " -296.226   68.95   11 0.0000E+00 0.0000E+00 0.0000E+00
0.5800     0.4200     3.4167e-02  7.8386e-04
"10/22/1996" "19:32:59" "PS PCM  lengths <5, 5-10, >=10 and widths <0.3, >=0.3 " -296.228   68.97   11 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00  0.0000E+00  0.6171     0.3829     3.4084e-02  8.9173e-04
"10/22/1996" "19:32:59" "PS PCM  lengths <5, 5-10, >=10 and widths <0.4, >=0.4 " -296.124   68.75   11 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00  0.0000E+00  0.6218     0.3782     3.3966e-02  8.6454e-04
"10/22/1996" "19:32:59" "PS PCM  lengths <5, 5-10, >=10 and widths <0.5, >=0.5 " -296.226   68.95   11 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00  0.0000E+00  0.5800     0.4200     3.4167e-02  7.8386e-04

"10/22/1996" "19:33:00" "SC PCM  lengths <10, >=10                             " -292.283   56.96   12 0.0000E+00 0.0000E+00  1.000
3.0399e-02  3.8864e-04
"10/22/1996" "19:33:01" "SC PCM  lengths >=10                                  " -292.283   56.96   12 0.0000E+00  1.000      3.0399e-02
3.8864e-04
"10/22/1996" "19:33:01" "SC PCM  lengths >=10 and widths < 0.3                 " -301.778   90.24   12 0.0000E+00  1.000      4.3548e-02
1.2887e-03
"10/22/1996" "19:33:01" "SC PCM  lengths >=10 and widths < 0.4                 " -300.564   87.30   12 0.0000E+00  1.000      4.2830e-02
8.0126e-04
"10/22/1996" "19:33:02" "SC PCM  lengths >=10 and widths < 0.5                 " -299.230   80.93   12 0.0000E+00  1.000      4.0893e-02
5.9682e-04
"10/22/1996" "19:33:02" "SC PCM  lengths >=10 and widths >=0.3                 " -291.282   53.08   12 0.0000E+00  1.000      3.0016e-02
5.3901e-04
"10/22/1996" "19:33:02" "SC PCM  lengths >=10 and widths >=0.4                 " -291.615   53.13   12 0.0000E+00  1.000      3.0601e-02
7.0335e-04
"10/22/1996" "19:33:03" "SC PCM  lengths >=10 and widths >=0.5                 " -289.538   47.01   12 0.0000E+00  1.000      2.8679e-02
1.0040e-03
"10/22/1996" "19:33:03" "SC PCM  lengths <10, >=10 and widths <0.3, >=0.3      " -291.282   53.08   12 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00  1.000      3.0016e-02  5.3901e-04
"10/22/1996" "19:33:03" "SC PCM  lengths <10, >=10 and widths <0.4, >=0.4      " -291.297   53.07   11 0.0000E+00 0.0000E+00 0.0000E+00
0.1906     0.8094     2.9857e-02  7.3280e-04
"10/22/1996" "19:33:03" "SC PCM  lengths <10, >=10 and widths <0.5, >=0.5      " -289.410   47.20   11 0.0000E+00 0.0000E+00 0.0000E+00
6.8701e-02  0.9313     2.8234e-02  9.6970e-04
"10/22/1996" "19:33:04" "SC PCM  lengths <5, 5-10, >=10 and widths <0.3, >=0.3 " -291.282   53.08   12 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00  1.000     3.0016e-02  5.3901e-04
"10/22/1996" "19:33:04" "SC PCM  lengths <5, 5-10, >=10 and widths <0.4, >=0.4 " -291.297   53.07   11 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00  0.0000E+00  0.1906     0.8094     2.9857e-02  7.3280e-04
"10/22/1996" "19:33:05" "SC PCM  lengths <5, 5-10, >=10 and widths <0.5, >=0.5 " -289.410   47.20   11 0.0000E+00 0.0000E+00 0.0000E+00
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0.0000E+00  0.0000E+00  6.8701e-02  0.9313      2.8234e-02  9.6970e-04

 "10/28/1996" "12:44:57" "DPS PCM  lengths <10, >=10                          " -287.949  44.46  12  0.0000E+00  0.0000E+00  1.000
2.5235e-02  5.1220e-04
 "10/28/1996" "12:44:57" "DPS PCM  lengths >=10                               " -287.949  44.46  12  0.0000E+00  1.000       2.5235e-02
5.1220e-04
 "10/28/1996" "12:44:58" "DPS PCM  lengths >=10 and widths < 0.3              " -316.503  110.2  12  0.0000E+00  1.000       7.3622e-02
5.6629e-03
 "10/28/1996" "12:44:58" "DPS PCM  lengths >=10 and widths < 0.4              " -300.922  82.23  12  0.0000E+00  1.000       4.4147e-02
3.4464e-03
 "10/28/1996" "12:44:58" "DPS PCM  lengths >=10 and widths < 0.5              " -293.750  61.78  12  0.0000E+00  1.000       3.5229e-02
2.3840e-03
 "10/28/1996" "12:44:58" "DPS PCM  lengths >=10 and widths >=0.3              " -289.658  48.05  12  0.0000E+00  1.000       2.6465e-02
5.4368e-04
 "10/28/1996" "12:44:59" "DPS PCM  lengths >=10 and widths >=0.4              " -291.088  51.44  12  0.0000E+00  1.000       2.7837e-02
5.8117e-04
 "10/28/1996" "12:44:59" "DPS PCM  lengths >=10 and widths >=0.5              " -292.360  54.33  12  0.0000E+00  1.000       2.8690e-02
6.2912e-04
 "10/28/1996" "12:44:59" "DPS PCM  lengths <10, >=10 and widths <0.3, >=0.3   " -286.566  41.86  11  0.0000E+00  0.0000E+00  0.0000E+00
0.7938      0.2062      2.4631e-02  2.1051e-03
 "10/28/1996" "12:45:00" "DPS PCM  lengths <10, >=10 and widths <0.4, >=0.4   " -286.586  41.99  11  0.0000E+00  0.0000E+00  0.0000E+00
0.7526      0.2474      2.4604e-02  1.6363e-03
 "10/28/1996" "12:45:00" "DPS PCM  lengths <10, >=10 and widths <0.5, >=0.5   " -286.449  41.81  11  0.0000E+00  0.0000E+00  0.0000E+00
0.7528      0.2472      2.4906e-02  1.4683e-03
 "10/28/1996" "12:45:01" "DPS PCM  lengths <5, 5-10, >=10 and widths <0.3, >=0.3 " -286.566  41.86  11  0.0000E+00  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.7938      0.2062      2.4631e-02  2.1051e-03
 "10/28/1996" "12:45:01" "DPS PCM  lengths <5, 5-10, >=10 and widths <0.4, >=0.4 " -286.586  41.99  11  0.0000E+00  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.7526      0.2474      2.4604e-02  1.6363e-03
 "10/28/1996" "12:45:01" "DPS PCM  lengths <5, 5-10, >=10 and widths <0.5, >=0.5 " -286.449  41.81  11  0.0000E+00  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.7528      0.2472      2.4906e-02  1.4683e-03

 "10/28/1996" "12:45:03" "DSC PCM  lengths <10, >=10                          " -283.543  33.35  12  1.1074e-05  0.0000E+00  1.000
2.3313e-02  5.5129e-04
 "10/28/1996" "12:45:03" "DSC PCM  lengths >=10                               " -283.543  33.35  12  1.1074e-05  1.000       2.3313e-02
5.5129e-04
 "10/28/1996" "12:45:03" "DSC PCM  lengths >=10 and widths < 0.3              " -292.585  62.75  12  0.0000E+00  1.000       2.9350e-02
1.9603e-03
 "10/28/1996" "12:45:04" "DSC PCM  lengths >=10 and widths < 0.4              " -291.994  61.26  12  0.0000E+00  1.000       2.9669e-02
1.2027e-03
 "10/28/1996" "12:45:04" "DSC PCM  lengths >=10 and widths < 0.5              " -288.758  50.76  12  0.0000E+00  1.000       2.7648e-02
9.0725e-04
 "10/28/1996" "12:45:04" "DSC PCM  lengths >=10 and widths >=0.3              " -283.168  31.45  12  8.3897e-04  1.000       2.3906e-02
```

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7.5397e-04
 "10/28/1996" "12:45:05" "DSC PCM  lengths >=10 and widths >=0.4                              " -283.756   32.11   12 4.9080e-04  1.000       2.4780e-02
9.7866e-04
 "10/28/1996" "12:45:05" "DSC PCM  lengths >=10 and widths >=0.5                              " -284.839   33.82   12 0.0000E+00  1.000       2.5206e-02
1.3372e-03
 "10/28/1996" "12:45:05" "DSC PCM  lengths <10, >=10 and widths <0.3, >=0.3                   " -283.115   31.57   11 1.4270e-04  0.0000E+00  0.0000E+00
0.1662      0.8338      2.3616e-02  8.4322e-04
 "10/28/1996" "12:45:06" "DSC PCM  lengths <10, >=10 and widths <0.4, >=0.4                   " -283.015   31.25   11 2.5114e-04  0.0000E+00  0.0000E+00
0.2851      0.7149      2.3447e-02  1.0489e-03
 "10/28/1996" "12:45:06" "DSC PCM  lengths <10, >=10 and widths <0.5, >=0.5                   " -283.016   31.11   11 3.0503e-04  0.0000E+00  0.0000E+00
0.3050      0.6950      2.3103e-02  1.1895e-03
 "10/28/1996" "12:45:06" "DSC PCM  lengths <5, 5-10, >=10 and widths <0.3, >=0.3             " -283.115   31.57   11 1.4270e-04  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.1662      0.8338      2.3616e-02  8.4322e-04
 "10/28/1996" "12:45:07" "DSC PCM  lengths <5, 5-10, >=10 and widths <0.4, >=0.4             " -283.015   31.25   11 2.5114e-04  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.2851      0.7149      2.3447e-02  1.0489e-03
 "10/28/1996" "12:45:07" "DSC PCM  lengths <5, 5-10, >=10 and widths <0.5, >=0.5             " -283.016   31.11   11 3.0503e-04  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.3050      0.6950      2.3103e-02  1.1895e-03
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APPENDIX D: THE VARIATION IN K_L VALUES DERIVED FOR CHRYSOTILE MINERS AND CHRYSOTILE TEXTILE WORKERS

The difference between the observed risk of lung cancer for comparable levels of chrysotile exposure among Quebec miners (most recent followup: Liddell et al. 1997) and South Carolina textile workers (Dement et al. 1994; McDonald et al. 1983a) has been the focus of much attention. Reasonably good agreement between results from the Quebec studies and another study of chrysotile miners in Italy (Piolatto et al. 1990) coupled with reasonably good agreement between results from the South Carolina Plant and results from textile plants in Mannheim, Pennsylvania (McDonald et al. 1983b) and in Roachdale, England (Peto 1980a,b; Peto et al. 1985) suggest that the difference between Quebec and South Carolina may reflect a general difference between the two industries (see Table 7-6 and Section 7.2.2). This appears true despite the fact, for example, that cohorts at two of the textile plants were apparently exposed to significant amounts of amphibole in addition to chrysotile (see Appendix A and Section 7.2.2).

Three main hypotheses have been advanced to explain the difference in the risk per unit exposure observed among miners and textile workers (see, for example, Sebastien et al. 1989). These are:

(1) the low reliability of exposure estimates in the various studies;

(2) differences in fiber size distributions in the two industries (with textile-related exposures presumably involving greater fractions of longer fibers); or

(3) simultaneous exposure to a co-carcinogen (i.e., oil that may have been sprayed on the asbestos fibers) in the textile industry.

It has also been proposed that differences in the concentration of long tremolite (amphibole) fibers in dusts from each of the two industries might represent an explanatory factor (see, for example, McDonald 1998b). However, this would also require a large relative difference between the potencies of tremolite (amphiboles) and chrysotile toward the induction of lung cancer. This latter issue is addressed further in Sections 7.4–7.6. McDonald (1998b) also presents an overview of the current status of each of the hypotheses described above.

In an attempt to distinguish among the above-listed hypotheses, Sebastien et al. (1989) conducted a study to determine lung fiber concentrations in tissue samples from deceased members of the cohorts studied from both the Quebec mines (specifically, from the Thetford mine) and the South Carolina textile plant. These researchers ultimately analyzed tissue samples from 72 members of the South Carolina cohort and 89 members of the Thetford (Quebec) cohort. Because the tissue samples came from cohort members, they could be matched with estimates of the exposure experienced by each of the individuals as well as details concerning the age at first employment, the age at death, the years of employment, and the number of years following employment until death.

In the Sebastien et al. (1989) study, tissue samples were obtained in formalin-fixed or paraffin blocks, which were then digested in bleach, filtered, and analyzed by TEM. Tissue samples were apparently "opportunistic." Only fibers longer than 5 μm with an aspect ratio >3:1 were included in the count. For consideration of the limitations associated with such preparations, see Section 5.2.

Results from matching of tissue samples with the histories of corresponding cohort members indicate that tissue samples obtained from each cohort covered a broad range of exposure levels, duration of exposure, and years since the end of exposure. They also indicate that South Carolina cohort members included in the Sebastien et al. (1989) study experienced, on average, 13.5 years of exposure with 18.1 years between the end of exposure and death. In contrast, Thetford workers included in this study experienced an average of 32.6 years of exposure with only 11.6 years between the end of exposure and death. Corresponding to differences in exposure levels observed across the two cohorts in the original epidemiology studies, mean exposure levels experienced by Thetford cohort members included in this study were about 10 times mean exposure levels experienced by South Carolina workers (19.5 mpcf vs. 1.9 mpcf).

Because Sebastien and coworkers recognized the general lack of a good model describing the retention and clearance of asbestos fibers in the lungs at the time their study was conducted, they performed most of their analyses either on pairs of members (one from each cohort) matched for duration of exposure and time since end of exposure or on groups of members from each cohort similarly stratified by duration of exposure and time since end of exposure.

Results from their study indicate that, overall, lung burdens observed among Thetford cohort members are substantially higher than those observed among South Carolina cohort members. Geometric mean lung chrysotile concentrations are reported to be 5.3 and 0.63 fibers/μg dry lung tissue in Thetford workers and South Carolina workers, respectively. Furthermore, despite tremolite representing only a minor contaminant in the chrysotile from Quebec and the dusts to which the miners were exposed (Sebastien et al. 1986), the majority of fibers observed in the lungs of Thetford miners were in fact tremolite (mean concentration 18.4 f/μg dry lung). Since the raw material used in the South Carolina plant came largely from Quebec, tremolite was also expected to be a minor contaminant in the dusts to which textile workers were exposed. Yet among these workers also, tremolite represented a substantial fraction of the lung fibers observed (mean concentration 0.36 f/μg). Thus, the ratio of tremolite concentrations observed among Thetford miners and that observed among South Carolina workers (18.4:0.36, or 51) is even more extreme than the ratio observed for chrysotile (8.4).

To evaluate the first of the above-listed hypotheses, it is instructive to compare the ratios of chrysotile or tremolite fibers observed in the lungs of deceased workers from Thetford and South Carolina, respectively, with the overall exposures that each received. A rough estimate of cumulative exposure for each set of workers in the Sebastien et al. (1989) study representing each cohort can be derived as the product of the mean duration of exposure and the mean intensity of exposure. Thus, for example, mean cumulative exposure in Thetford was 32.6 yearsx19.5 mpcf or 635.7 mpcf-yrs. Similarly, for South Carolina, mean cumulative exposure was 25.65 mpcf-yrs, which gives a Thetford/South Carolina ratio of 24.8. This presumably represents the relative cumulative exposure to chrysotile. For tremolite, Sebastien and coworkers report that, based on a regression analysis, the fraction of tremolite fibers among total

asbestos fibers were likely only 0.4 times as much in South Carolina as in Thetford (where they likely averaged 1% of total fibers). Therefore, the ratio of cumulative exposures to tremolite for the sets of cohort members studied by Sebastien and coworkers is likely 62.

Comparing the ratio of Thetford:South Carolina lung burden estimates with the ratios of the corresponding cumulative exposures, it appears that the chrysotile lung burden ratio (8.4) is only a third of the ratio predicted based on cumulative exposure (24.8). However, the ratio of lung tremolite concentrations (51) is much closer to the corresponding cumulative exposure ratio (62). It thus appears that, although, airborne concentrations may not closely track the exposures that led to the observed lung burdens for individuals (see below), the overall trend in exposures predicted by airborne measurements is approximately correct. It is therefore likely that overall exposure concentrations in Thetford were in fact substantially higher than in South Carolina (in agreement with airborne measurements). Thus, we concur with Sebastien et al. that the unreliability of exposure estimates in these two cohorts is unlikely to explain the observed difference in the risk per unit of exposure observed for each cohort.

Importantly, although the general trend in relative overall exposure levels predicted by airborne measurements between Thetford and South Carolina appear to have been confirmed by mean lung fiber concentrations in the Sebastien et al. (1989) study, the estimated exposures correlate poorly with lung burdens for any particular individual. To demonstrate this, we analyzed the Thetford:South Carolina ratios of lung chrysotile concentrations and, separately, lung tremolite concentrations reported by Sebastien et al. for their set of 32 matched pairs of cohort workers to determine whether trends in these ratios adequately matched trends in the corresponding estimated airborne exposure level ratios for the same matched pairs. To do this, we subjected the ratios presented in Table 7 of the Sebastien et al. (1989) study to a Rank Von Neuman test (Gilbert 1987). Results indicate that trends in neither lung chrysotile concentration ratios nor lung tremolite concentration ratios can be predicted by the observed trend in the estimated airborne concentration ratios among these 32 matched pairs.

There are numerous sources of potential uncertainty that may mask the relationship between airborne exposure estimates and resulting lung burdens (Section 5.2). Potentially the largest of these is the variation expected among lung burden estimates derived from use of "opportunistic" tissue samples, which are not controlled for the portion of the respiratory tree represented by the sample. Even for samples collected from adjacent locations in lung parenchyma, observed fiber concentrations may vary substantially and such variation is magnified between samples taken from different individuals at locations in the lung that may not in any way correspond to their relative position in the respiratory tree.

Other potentially important sources of variation that may mask the relationship between airborne exposure concentrations and resulting lung burden estimates may primarily involve limitations in the degree to which the airborne estimates from an epidemiology study represent actual exposures to the individual members of a study cohort (Section 5.1). The following factors may all contribute to the uncertainty of exposure estimates:potential differences between individual exposures versus area concentrations (which are what is typically measured), the adequacy of extrapolation to the earliest exposures in a cohort (when measurements were generally not available), or the adequacy of estimating job x time matrices for individual workers that can then be integrated with work area exposure estimates to derive individual exposure estimates.

The second of the above-listed hypotheses, involves potential differences in the size of structures that may have been present in the airborne concentrations in Thetford and South Carolina, which may not have been adequately represented by the exposure measurements. More generally, this is a question of the degree to which measured exposures in the two environments adequately reflect potential differences in the character of exposure that relate to biological activity.

Sebastien et al. (1989) considered this second hypothesis by generating and comparing size distributions for the fibers observed in the lungs of workers from Thetford and, separately, South Carolina. Importantly, the size distributions for each cohort were generated by including the first five fibers observed from every member of that cohort, without regard to the duration of exposure, level of exposure, or time since exposure experienced by each cohort member. Therefore, the size distributions obtained are "averaged" over very different time frames during which differing degrees of fiber retention and clearance will have taken place, each of which potentially alters the distributions of fiber sizes (Section 6.2). Thus, the two distributions generated are each actually collections of samples from multiple, varied size distributions (rather than single distributions) and this likely masks distinctions between the two work environments. It is therefore not surprising that the authors found relatively little differences in the two size distributions.

The portion of the generated size distributions that are least likely to have been affected by the limitations due to the manner in which they are generated (as Sebastien et al. suggest) is the fraction of tremolite (amphibole) fibers longer than 20 µm. This is because (1) tremolite fibers (unlike chrysotile) are biodurable and (2) biodurable fibers longer than approximately 20 µm have been shown to clear from the lung only very slowly, if at all (Section 6.2). Thus, the Thetford:South Carolina ratio of long tremolite fibers may provide the best indication of the relative exposures to long fibers in the two environments.

Table D-1 presents the estimated, relative concentrations of specific lengths of fibers observed in lung tissue among Thetford miners and South Carolina workers, respectively. The length category for various fibers is presented in the last column of the table. The estimated concentrations, presented in Columns 2 (for Thetford) and 3 (for South Carolina) of this table were derived as follows. For the first length category (L>5 µm), concentrations are taken directly from Table 5 of the Sebastien et al. (1989) paper (the geometric means are presented). Concentrations for the remaining length categories were estimated by multiplying the concentrations for this first length category by the fraction of the size distribution represented by each succeeding length category (as provided in Table 4 of the Sebastien et al. paper). So that the relative precision of these concentration estimates can be evaluated, an estimate of the numbers of fibers included in each length category (from the total used to derive the size distribution in Table 4 of Sebastien et al.) are provided in Columns 6 (for Thetford) and 7 (for South Carolina), respectively. The Thetford:South Carolina ratios of the concentrations of fibers in each length category (for each fiber type) are provided in Column 5 of the table.

Table D-1. Estimated Concentrations of Sized Fibers Observed in the Lungs of Thetford Miners and South Carolina Textile Workers[a]

	MEAN LUNG CONCENTRATION				NUMBER OF FIBERS		
Fiber Type	Thetford	South Carolina	Units	Ratio: Th/SC	Thetford	South Carolina	Size Range of Fibers[b]
Chrys	5.3	0.63	f/μg lung	8.41	371	226	Length>5 μm
Trem	18.4	0.38	f/μg lung	48.42	405	175	
Chrys	1.73	0.17	f/μg lung	10.00	121	62	Length>8 μm
Trem	3.90	0.091	f/μg lung	42.95	86	42	
Chrys	0.59	0.070	f/μg lung	8.41	41	25	Length>13μm
Trem	0.72	0.024	f/μg lung	30.46	16	11	
Chrys	0.16	0.031	f/μg lung	5.15	11	11	Length>20μm
Trem	0.037	0.008	f/μg lung	4.40	1	4	

[a]Derived from data presented in Tables 4 and 5 of Sebastien et al. (1989)
[b]Geometric mean

It is instructive to compare the ratios presented in Table D-1 to the Thetford:South Carolina ratios of mean cumulative exposures estimated above for chrysotile and tremolite among the cohort members included in the Sebastien et al. (1989) study (24.8 and 62, respectively). As indicated in Table D-1, for chrysotile, the ratio remains approximately constant at about 9 (varying only between 8.4 and 10) for all of the size ranges reported except the longest. For the longest category (L>20), however, the ratio drops to 5. Because fibers longer than 20 μm are expected to be the most persistent in the body (Section 6.2), it may be that the ratio of 5 best represents the relative concentration of long chrysotile structures among the two sets of cohort members.

Because this ratio (for the long fibers found in the lung) is only approximately 1/5 of the estimated ratio for the cumulative exposure to chrysotile (24.8), this suggests that the South Carolina cohort may indeed have been exposed to dusts enriched in long fibers relative to dusts experienced at Thetford. Because the estimate of this ratio is based on counts of at least 11 fibers from Thetford and South Carolina, respectively, it is unlikely that this ratio will vary by more than a factor of 2 or 3 (the 95% CI around 11 fibers, based on a Poisson distribution is 6–19).

The trend with tremolite is even more striking. Moreover, as previously indicated, because tremolite fibers are biodurable, it is the tremolite fibers longer than 20 μm that may best represent the ratio of long fibers to which these two groups of cohort members were exposed. The ratios observed among tremolite fibers steadily decrease from approximately 50 for fibers longer than 5 μm to 4.4 for fibers longer than 20 μm, although this last value is uncertain (due to it being based on only 1 fiber observed among Thetford-derived lungs and only 4 fibers among South Carolina-derived lungs). In fact these data are statistically consistent even with a ratio considerably less than 1, (i.e., with a considerably higher concentration of long tremolite fibers in South Carolina than in Quebec). Given that the ratio of the original cumulative exposures for tremolite was estimated to be 62, that the ratio of long tremolite fibers is only 4.4 suggests that dusts in South Carolina may have been highly enriched in long fibers.

Observations that the fibers to which textile workers were exposed were longer and thinner than those found in mining are further supported by various published size distributions of fibers determined in air samples collected in these environments (see, for example, Gibbs and Hwang 1975, 1980). Also, as noted in Crump (1986), the raw fiber purchased by textile plants was commonly described as the longest grade of product (see Table 22 of Crump). Size issues are addressed further in Section 7.4.

The data in a more recent study by Case et al. (2000) demonstrates even more strongly that South Carolina textile workers were exposed to fibers that were substantially longer than those inhaled by Quebec miners and millers. In this study, lung fiber contents were determined for 64 deceased textile workers and 43 deceased chrysotile miners and millers, respectively, which represent randomly selected subsets of the workers, miners, and millers for whom lung burdens were previously described by Sebastien et al. (1989), as discussed above.

In the Case et al. (2000) study, analyses were conducted on sets of TEM specimen grids that had originally been prepared in the Sebastien et al. (1989) study, thus selection of subjects and the preparation of samples in this study is the same as described above for the Sebastien et al. study. However, Case et al. focused specifically on the counting of fibers longer than 18 μm.

Results from the Case et al. (2000) study are summarized in Table D-2. As indicated in the second column of Table D-2, the mean cumulative exposure to which the selected cohort members from Quebec and South Carolina were exposed in this study was 186 and 3.63 mpcf-y (millions of particles per cubic ft-years), respectively. This gives a Quebec/South Carolina ratio of approximately 51. In contrast the Quebec/South Carolina ratios of the concentrations of asbestos fibers observed in lungs among these selected cohort members are substantially smaller (4.28 for long chrysotile, 12.04 for long tremolite, and 5.45 for long amphibole). This implies that the lungs of South Carolina workers are substantially enriched in these long fibers relative to the lungs of Quebec miners and millers. Moreover, because substantial numbers of long fibers were counted in these analyses, the uncertainty of these ratios is relatively small.

TABLE D-2. ESTIMATED MEAN AIRBORNE EXPOSURE CONCENTRATIONS AND ASSOCIATED LUNG FIBER BURDENS FOR A SELECTED SET OF TEXTILE WORKERS, MINERS, AND MILLERS[a]

Location	Mean Airborne Exposure Concentration (mpcfy)	Lung Chrysotile Content (long fibers) (f/μg)	Lung Tremolite Content (long fibers) (f/μg)	Lung Total Amphibole Content (long fibers) (f/μg)
Quebec Mining	186	0.231	0.325	0.349
SC Textiles	3.63	0.054	0.027	0.064
Ratio	**51.24**	**4.28**	**12.04**	**5.45**

[a]Derived from data presented in Table 2 of Case et al. (2000)

If the estimated K_L's derived for Quebec miners (0.00029) and South Carolina textile workers (0.021), as reported in Table 7-6, are adjusted to account for the relative concentrations of long fibers reported by Case et al. the disparity in these K_L estimates effectively disappears. If adjusted as described in Section 7.4.2, the new K_{L*}'s for Quebec (0.234) and for South Carolina (1.21) now differ by only a factor of 5 (rather than the original factor of 72). Thus, accounting for long structures appears to reconcile these potency estimates.

The data presented by Case et al. (2000) also indicates that the lungs of textile workers in South Carolina (but not those of Quebec miners) contain substantial concentrations of commercial amphibole asbestos fibers (amosite and crocidolite) in addition to tremolite. In fact, the majority of the amphibole fibers observed in lungs from South Carolina workers were composed of the commercial amphibole types. This suggests, among other things, that the exposure environment in South Carolina should actually be characterized as a mixed exposure environment rather than a chrysotile exposure environment. As indicated in the following two paragraphs, however, conclusions concerning the nature of the general exposure environments in Quebec mines or the South Carolina textile mill that are based only on observations among the small subsets of these cohorts examined by Case et al. may not be robust.

Importantly, Case et al. indicate in their paper that, because they observed substantially greater absolute numbers of long fibers in the lungs of Quebec miners than in the lungs of South Carolina workers, they conclude that (regardless of the above analysis), Quebec miners were still exposed to a greater absolute number of long fibers than South Carolina workers. However, this does not appear to be a valid conclusion that can be derived from the data provided in the paper.

We compared the mean exposure concentrations reported for the subset of Quebec miners and South Carolina textile workers that Case et al. (2000) examined (Table D-2) to the distribution of exposures reported among the entire cohorts in Quebec (Table A-2) and South Carolina (Table A-8), respectively. Results suggest that, exposures for the subset of Quebec cohort members included in the Case et al. study are higher than approximately 75% of the exposures experienced by the overall cohort. In contrast, exposures for the subset of the textile worker cohort examined by Case et al. are lower than approximately 50% of exposures experienced in the overall cohort. Thus, given that the mean exposures experienced by the subsets of each cohort examined by Case et al. do not reflect mean exposures for the respective cohorts as a whole, it is not reasonable to compare absolute numbers of structures observed in the lungs of these workers and draw general conclusions about the relative, absolute exposures among the entire, respective cohorts.

At this point it is worth mentioning some of the potential differences in the characteristics of mining dusts and textile mill dusts that may affect biological activity, but that may not be adequately delineated when measuring exposures by PCM (in f/ml) and almost certainly not delineated when exposures are measured by midget impinger (in mpcf), see Section 4.3. During the mining of asbestos, only a small fraction of the rock (generally no more than 10%) that is mined is typically composed of the fibers of interest.

While the host rock in a mine may be of similar chemical composition, it generally represents an entirely different crystalline habit. Nevertheless, a large fraction of the dust that is created during mining is likely composed of fragments from the host rock and many of these fragments

will be of a size that would be included in the particles counted by midget impinger. Furthermore, at least some fraction of the fragments created by the crushing and cutting of the host rock will be elongated "cleavage" fragments (Section 4.0) so that at least some fraction of these may be included even in PCM counts, despite many of them being either too thick to be respirable, or too short or thick to be biologically active (see Section 6.2). Note, although Sebastien et al. (1989) employed TEM to characterize fibers in the study, they apparently employed a fiber definition that was sufficiently broad that they too would have counted large numbers of structures that may be too short or too thick to contribute to biological activity.

In comparison, the dusts created in a textile factory are likely composed almost exclusively of true asbestos fibers. The raw material received by the factory will already have been milled and beneficiated to remove the vast majority of non-fibrous material. It is therefore, much less likely that extraneous fragments (even cleavage fragments) exist that might be counted either by midget impinger or PCM. We make this point because, if this represents the true situation, it would be expected that risk per unit exposure estimates (i.e., exposure-response factors) derived from any mining site, may be smaller than estimates derived for the same fiber type in occupational environments where only finished fiber is used. Thus, another interpretation of the variation observed among estimated K_L values for amphiboles (reported in Section 7.2.2) is that mining values are somewhat low. As later described (Section 7.3.2), the same may be true for amphibole K_M values. The implications of this possibility are discussed further in each respective section.

Note, although the Sebastien et al. (1989) paper suggests that (mpcf) exposure estimates from Thetford and South Carolina grossly suggest the relative range of lung burdens observed, there is too much scatter in the data to determine how closely the air ratios track the lung burden ratios. For example, ratios derived from arithmetic means (rather than the geometric means) for the Sebastien et al. data are substantially different. Moreover, as indicated above, there may be substantially different size distributions in the two environments, which might at least in part be explained by the inclusion of large numbers of cleavage fragments (with dimensions inappropriate for biological activity) in the mining environment.

Although the third of the above-listed hypotheses was not addressed by Sebastien and coworkers, the question of whether a co-carcinogen contributes to the overall observed lung cancer rate among textile workers has been considered by several other researchers. To test the hypothesis of whether oils potentially contributed to disease in South Carolina, Dement and Brown (1994) performed a nested case-control study among a subset of the cohort members previously studied by Dement et al. (most recent update, 1994). In this analysis, Dement and Brown qualitatively assessed the probability of mineral oil exposure for cases and controls based on knowledge of historic descriptions of mineral oil use. The extent of such exposure was then further categorized into three strata: none or little, moderate, or heavy, based on where each worker was longest employed. Cases and controls were then further categorized based on years at risk and level of asbestos exposure. Results from this nested analysis indicated no significant change in the estimated exposure-response slope for asbestos after adjusting for mineral oil exposure.

Additional, albeit qualitative, evidence that oils may not represent an adequate explanation for the relative lung cancer risks observed in mining and textiles is provided by McDonald (1998b).

McDonald suggests that oils were not used in the Roachdale plant until 1974. Therefore, due to latency, it is unlikely that the use of such oils would have had a substantial impact on the observed lung cancer cases at the point in time that the study was conducted (Peto 1980a,b; Peto et al. 1985).

Taken as a whole, the evidence presented in this section suggests that the relative distribution of fiber sizes found in dusts in the textile industry and the mining industry, respectively, may be the leading hypothesis for explaining the observed differences in lung cancer risk per unit of exposure between these two industries.

REFERENCES

Case BW; Dufresne A; McDonald AD; McDonald JC; Sebastien P. Asbestos Fiber Type and Length in Lungs of Chrysotile Textile and Production Workers: Fibers Longer than 18 μm. *Inhalation Toxicology*. 1(Suppl 1):411–418. 2000.

Crump KS. Asbestos Potency Assessment for EPA Hearing. Prepared for Asbestos Information Association/North America. 116 pp. 1986.

Dement JM; Brown DP. Lung Cancer Mortality Among Asbestos Textile Workers: A Review and Update. *Annals of Occupational Hygiene*. 38(4):525–532. 1994.

Dement JM; Brown DP; Okun A. Follow-up Study of Chrysotile Asbestos Textile Workers: Cohort Mortality and Case-Control Analysis. *American Journal of Industrial Medicine*. 26:431–447. 1994.

Gibbs GW; Hwang CY. Physical Parameters of Airborne Asbestos Fibres in Various Work Environments - Preliminary Findings. *American Industrial Hygiene Association Journal*. 36(6):459–466. 1975.

Gibbs GW; Hwang CY. Dimensions of Airborne Asbestos Fibers. In *Biological Effects of Mineral Fibers*. Wagner JC (ed.). IARC Scientific Publication. pp. 69–78. 1980.

Gilbert O. *Statistical Method for Environmental Pollution Monitoring*. Van Nostrand Reinhold, New York. 1987.

Liddell FDK; McDonald AD; McDonald JC.. The 1891–1920 Birth Cohort of Quebec Chrysotile Miners and Millers: Development From 1904 and Mortality to 1992. *Annals of Occupational Hygiene*. 41:13–36. 1997.

McDonald AD; Fry JS; Wooley AJ; McDonald JC. Dust Exposure and Mortality in an American Chrysotile Textile Plant. *British Journal of Industrial Medicine*. 39:361–367. 1983a.

McDonald AD; Fry JS; Woolley AJ; McDonald JC. Dust Exposure and Mortality in an American Factory Using Chrysotile, Amosite, and Crocidolite in Mainly Textile Manufacture. *British Journal of Industrial Medicine*. 40:368–374. 1983b.

McDonald JC. Invited Editorial: Unfinished Business - The Asbestos Textiles Mystery. *Annals of Occupational Hygiene*. 42(1):3–5. 1998b.

Peto J. Lung Cancer Mortality in Relation to Measured Dust Levels in an Asbestos Textile Factory. In *Biological Effects of Mineral Fibres*. Wagner JC (ed.). IARC Scientific Publications. pp. 829–836. 1980a.

Peto J. The Incidence of Pleural Mesothelioma in Chrysotile Asbestos Textile Workers. In *Biological Effects of Mineral Fibres*. Wagner JC (ed.). IARC Scientific Publications. pp. 703–711. 1980b.

Peto J; Doll R; Hermon C; Binns W; Clayton R; Goffe T. Relationship of Mortality to Measures of Environmental Asbestos Pollution in an Asbestos Textile Factory. *Annals of Occupational Hygiene*. 29(3):305–355. 1985.

Piolatto G; Negri E; LaVecchia C; Pira E; Decarli A; Peto J. An Update of Cancer Mortality Among Chrysotile Asbestos Miners in Balangero, Northern Italy. *British Journal of Industrial Medicine*. 47:810–814. 1990.

Sebastien P; Plourde M; Robb R; Ross M; Nadon B; Wypruk T. Ambient Air Asbestos Survey in Quebec Mining Towns. Part II: Main Study. Environmental Protection Service, Environment Canada. EPS 5/AP/RQ/2E. July. 1986.

Sebastien P; McDonald JC; McDonald AD; Case B; Harley R. Respiratory Cancer in Chrysotile Textile and Mining Industries: Exposure Inferences from Lung Analysis. *British Journal of Industrial Medicine*. 46:180–187. 1989.

APPENDIX E: CALCULATION OF LIFETIME RISKS OF DYING OF LUNG CANCER OR MESOTHELIOMA FROM ASBESTOS EXPOSURE

This appendix describes how additional lifetime risk of lung cancer and mesothelioma are calculated from the estimated K_L, the potency for lung cancer, and K_M, the potency for mesothelioma. Let $S_E(t \mid x)$ be the probability of surviving to age t, given survival to age x <t, under some pattern E of asbestos exposure, let $M_E(t)$ be the mortality rate at age t for a given cause (i.e., lung cancer or mesothelioma) under exposure pattern E. For a small age increment, Δt, the probability of dying of the given cause between age t and $t+\Delta t$, given survival to age t, is $M_E(t)*\Delta t$. The corresponding probability of dying given survival to age x_1 is the probability, $S_E(t \mid x_1)$, of surviving to age t given survival to age x_1, times the probability of dying from the given cause given survival to age t, or

$$S_E(t \mid x_1) * M_E(t) * \Delta t \qquad \text{(Eq. E-1)}$$

The probability of dying of the given cause between ages x_1 and x_2 given survival to age x_1 is therefore given by the integral

(Eq. E-2)

$$P_E(x_1, x_2) = \int_{x_1}^{x_2} S_E(t \mid x_1) * M_E(t)\, dt$$

and the additional probability of dying from the given cause as a result of exposure pattern E is

$$P_E(x_1, x_2) - P_O(x_1, x_2) \qquad \text{(Eq. E-3)}$$

where the subscript 0 indicates no asbestos exposure.

The lung cancer and mesothelioma models in Sections A.1 and A.2 model the mortality rate, $M_E(t)$. It is shown below how expressions (Eq. E-2 and E-3) are implemented to convert estimates of mortality rate obtained from the lung cancer and mesothelioma models into estimates of additional risk defined by equation (Eq. E-3).

Let b_i, i=1 to n, represent the mortality rate from all causes for persons in the age interval (t_i-1, t_i), where ti-1 <ti and $t_0=0$, and let a_i be the corresponding mortality rate for lung cancer. Typically, mortality rates are reported for 5-year age-intervals as the number of deaths in a given calendar year per 100,000 persons alive at the beginning of the year, in which case $\Delta_i=5$ and b_i is the reported value for all-cause mortality divided by 100,000. Let Δ_i be the width of the interval (termed the "i[th] observational interval") formed by the intersection of the age-interval (t_i-1, t_i) and the interval (x_1, x_2) representing the age-interval over which we wish to calculate the probability of dying of lung cancer. For an unexposed person, the probability of dying of lung cancer in the

i^{th} observational interval, given survival to the beginning of the interval, is calculated as $a_i*\Delta_i$ (risk per person-year times years of observation), and the probability of surviving this age interval, given survival to the beginning of the interval, is calculated as $S_i=1-b_i*\Delta_i$. The probability of surviving to the beginning of the i^{th} interval given survival to age x_1 is calculated recursively as

$$\prod_{j=0}^{i-1} S_j \qquad \text{(Eq. E-4)}$$

where, by definition, $S_0\equiv 1$. The probability $P_0(x_1, x_2)$ of dying of lung cancer between x_1 and x_2, given survival to x_1, is the sum over each observational interval of the probability of surviving to the beginning of the age-interval times the probability of dying of lung cancer in the interval given survival to the beginning of the interval, or

$$P_0(x_1,x_2)=\sum_{i=1}^{n}\left(\prod_{j=0}^{i-1} S_j\right)*a_i*\Delta_i \qquad \text{(Eq. E-5)}$$

This expression represents a discrete approximation to the integral (Eq. E-2).

We now indicate how this expression is modified to account for exposure. First suppose the exposure pattern E is a step function defined by constant exposure to f (in units of the optimal exposure index) between ages e_1 and e_2, with no exposure at other ages. According to the lung cancer model (Eq. A-1), in the presence of exposure the mortality rate ai for the i^{th} observational interval is increased to $ai*(1+KL*d_i)$, where di is the cumulative exposure lagged 10 years for this interval. In the implementation of this algorithm, d_i is calculated as

$$d_i=\begin{cases} 0, & \text{if } m_i<e_1+10 \\ f*(m_i-e_1-10), & \text{if } e_1+10\le m_i<e_2+10 \\ f*(e_2-e_1,) & \text{if } e_2+10\le m_i \end{cases} \qquad \text{(Eq. E-6)}$$

where m_i is the midpoint of the i^{th} observational interval.

Thus, to account for exposure, a_i in expression (Eq. E-5) is replaced by $a_i*(1+K_L*d_i)$. The survival probabilities, S_i, in (Eq. E-5) must be modified to account for the affect of exposure upon both mesothelioma and lung cancer. Applying the mesothelioma model (Eq. A-3), the mesothelioma mortality rate in the i^{th} observational interval is K_M*Q_i, where K_M is the mesothelioma potency factor, and

$$Q_i=\begin{cases} 0, & \text{if } m_i<e_1+10 \\ f*(m_i-e_1-10)^3, & \text{if } e_1+10\le m_i<e_2+10 \\ f*\left[(m_i-e_1-10)^3-(m_i-e_2-10)^3\right], & \text{if } e_2+10<m_i \end{cases} \qquad \text{(Eq. E-7)}$$

Thus, to account for the dose-related effects of both lung cancer and mesothelioma upon survival, $S_i=1-b_i*\Delta$ i is replaced by

$$S_i(E)=1-(b_i-a_i*K_L*d_i-K_M*Q_i)*\Delta_i \quad \text{(Eq. E-8)}$$

Similarly, the probability of dying of mesothelioma from exposure pattern E between the ages of x_1 and x_2, given survival to x_1, is calculated as

$$K_M*f*\sum_{i=1}^{n}\prod_{j=0}^{i-1}S_j(E)*Q_i*\Delta_i \quad \text{(Eq. E-9)}$$

The oldest (n^{th}) age-interval is unbounded above. In the implementation of the algorithm, a width of 1/bn is assigned to this interval, which is an estimate of the average survival time in this age-interval. When, as is typical, the oldest interval is for ages ≥85 years, this assignment only affects the calculation when the followup period extends past 85 years (x_2>85), and then only minimally.

When used to estimate risk from continuous exposure (24 hours/day, 7 days/week), K_L and K_M were adjusted upward by multiplying by 365/240 (to adjust from an assumed occupational exposure of 240 days/year to 365 days/year) and by 2.0 (to adjust from an assumed exposure during work hours to 24 hours/day, assuming that the amount of air breathed during 24 hours is roughly double the amount breathed during a single work shift.

This algorithm is expanded to handle dose patterns composed of any linear combination of step functions simply by replacing d_i and Q_i by the sum of the corresponding terms resulting from each step function that composes the linear combination. Since any exposure pattern of interest can be approximated to any degree or accuracy by a linear combination of step functions, the algorithm can consequently estimate risk from any exposure pattern of interest.

Age-specific mortality rates for both lung cancer (a_i) and all-causes (b_i) are needed to calculate asbestos-related risk using the above approach. In order to account for differences in asbestos-related risk between males and females and—particularly for lung cancer—between smokers and non-smokers, it is necessary to apply sex- and smoking-specific mortality rates. Lung cancer and all-cause mortality rates for U.S. males and females for the year 2000 (CDC 2003) are provided in Table E-1. Also provided in this table are corresponding rates for never-smokers and current smokers, which were calculated from the U.S. 2000 rates, data on the effect of smoking obtained from the Cancer Prevention Study II (CPS-II) of the American Cancer Society (Thun et al. 1997a), and information on the prevalence of smoking obtained from the National Health Interview Survey (NHIS) (Trosclair et al. 2002). The following paragraphs describe how these smoking-specific rates were calculated.

Table E-1. Mortality Rates for All Causes and Lung Cancer per 100,000 Population per Year

	All Causes			Lung Cancer		
Age	**U.S. 2000**	**Non-smokers**	**Smokers**	**U.S. 2000**	**Non-smokers**	**Smokers**
Males						
1	799.9	799.9	799.9	0	0	0
5	36.5	36.5	36.5	0	0	0
130	18.3	18.3	18.3	0	0	0
288	25.0	25.0	25.0	0	0	0
15-20	94.9	94.9	94.9	0	0	0
20-25	142.0	93.8	281.4	0	0	0
25-30	141.9	93.7	281.2	0.3	0.1	0.9
30-35	157.3	103.9	311.7	0.8	0.2	2.5
35-40	209.8	138.4	416.3	3.3	0.9	10.4
40-45	303.3	192.5	623.7	10.4	2.7	32.6
45-50	461.7	314.9	886.0	26.0	5.8	84.4
50-55	658.3	430.1	1318.1	54.6	8.1	189.1
55-60	1007.5	671.4	1979.1	118	15.7	413.8
60-65	1565.5	1087.1	2948.5	206.2	23.6	734.2
65-70	2399.3	1690.8	4447.7	327.5	42.6	1151.3
70-75	3705.4	2661.6	6723.1	444.0	59.7	1555
75-80	5591.2	4334.9	9223.2	507.3	80.9	1740
80-85	8956.9	7257.3	13870.5	549.6	128.4	1767.3
85+	16605.4	15651.1	19364.3	499.0	144.1	1525.2
Females						
1	654.3	654.3	654.3	0	0	0
5	29.1	29.1	29.1	0	0	0
130	14.5	14.5	14.5	0	0	0
288	16.6	16.6	16.6	0	0	0
15-20	40.0	40.0	40.0	0	0	0
20-25	48.2	48.2	48.2	0	0	0
25-30	56.5	56.5	56.5	0	0	0
30-35	76.0	76.0	76.0	0.9	0.3	3.2
35-40	115.1	112.7	124.2	2.6	0.8	9.3
40-45	172.2	171.7	174.2	8.1	2.6	29.0
45-50	254.0	207.6	428.5	16.6	3.2	67.2
50-55	386.3	324.1	620.3	35.1	11.2	125.0
55-60	611.8	486.0	1085.1	70.9	16.5	275.4
60-65	982.0	774.5	1762.6	122.3	32.1	461.5
65-70	1527.5	1199.7	2760.7	181.6	41.4	709.2
70-75	2381.8	1943.6	4030.4	238.7	81.6	829.6
75-80	3812.6	3230.0	6004.2	268.6	79.6	979.6
80-85	6444.8	5753.4	9045.8	272.8	118.0	855.3
85+	14768.6	13829.2	18302.3	213.5	84.7	698.2

CPS-II (Thun et al. 1997a) prospectively followed more than one million persons in the U.S.

beginning in 1982. Subjects were recruited by volunteers and were ≥30 years of age at the time of enrollment. Smoking status was determined by a questionnaire administered at the time of enrollment. Never smokers were defined as persons who had never smoked any tobacco product, and current smokers as persons who were cigarette smokers at the time of enrollment. Although follow-up has now been extended, following a recommendation of Dr. Thun (Thun 2003), the present calculations are based upon follow-up through 1988 (Thun et al. 1997a). There are two reasons for this: (1) follow-up past 1988 mostly involves older ages for which sufficient numbers of deaths had already occurred prior to 1988 to insure adequate statistical stability of mortality rates; and (2) more importantly, since smoking histories were not updated, with longer follow-up there is greater misclassification of persons who were classified as current smokers at time of enrollment, but who may have quit smoking during the follow-up.

Based on follow-up of the CPS-II cohort through 1988, Thun et al. (1997a) present age-specific mortality rates for a number of causes of death, including lung cancer and all-cause mortality, by 5-year age-intervals beginning at age 30. Separate tabulations are provided for never smokers and for current smokers in both males and females (reproduced in Table E-2). These rates are not necessarily representative of the general U.S. population. For example, a member of the CPS-II cohort is more likely to be college-educated, married, middle-class, and white (Thun et al. 1997b). Note also, that, despite the fact that smoking is a well-documented health risk, female smokers in CPS-II (Table E-2) had lower all-cause mortality than U.S. women in general (Table E-1). Consequently, rather than applying the CPS-II rates directly to the U.S. population, they are used only to estimate age- and sex-specific relative risks resulting from smoking. These relative risks are used in conjunction with estimates of the current fraction of smokers to partition the U.S. 2000 mortality rates between non-smokers and smokers. For a given age, sex and mortality cause (lung cancer or all-cause mortality), we write

$$r_{2000} = r_{NS} * \left(1 - p_{SM}\right) + r_{NS} * RR_{SM} * p_{SM} \qquad \text{(Eq. E-10)}$$

where r_{2000} is the U.S. 2000 mortality rate for the age, sex and cause category, p_{SM} is the proportion of smokers in the U.S. population, and RR_{SM} is the relative risk for smoking obtained from the CPS-II data (mortality rate in current smokers divided by mortality rate in non-smokers). The U.S. mortality rate for non-smokers, r_{NS}, is estimated by solving this equation. The corresponding U.S. rate for smokers is then estimated as the product of the rate in non-smokers and the relative risk for smoking, r_{NS}*RR_{SM}.

Table E-2. CPS-II Mortality Rates for All Causes and Lung Cancer per 100,000 Population per Year[a]

	All Causes		Lung Cancer[b]	
Age	**Non-smokers**	**Smokers**	**Non-smokers (adj)**	**Smokers (adj)**
Males				
25-30	—	—	(0.02)	(0.3)
30-35	—	—	(0.2)	(2.2)
35-40	72.9	219.3	4.6(0.6)	5.9(7.4)
40-45	93.7	303.6	0.0(1.5)	18.7(17.5)
45-50	151.8	427.1	6.0(2.8)	41.4
50-55	221.4	678.5	5.5(4.9)	115.3
55-60	367.7	1083.8	5.3(7.8)	206.1
60-65	672.6	1824.2	11.6	361.1
65-70	1096.7	2884.9	21.5	581.6
70-75	1846.6	4664.5	34.9	909
75-80	3441.2	7321.7	52	1118.3
80-85	5466.5	10447.8	89.2	1227.7
85+	11141.6	13784.9	86.8	919
Females				
30-35	—	—	(0.03)	(0.4)
35-40	80.6	88.8	2.0(0.2)	4.0(2.8)
40-45	109.3	110.9	0.0(0.8)	8.9(9.5)
45-50	122.4	252.6	1.9(2.0)	42.4
50-55	182.1	348.5	5.8	64.7
55-60	268.2	598.8	7.2	119.9
60-65	411.4	936.3	12.3	176.6
65-70	666.5	1533.7	16.7	286.3
70-75	1073.9	2227	30.5	310
75-80	1838.7	3417.9	32.5	400
80-85	3154.2	4959.2	57.6	417.6
85+	8069.2	10679.2	60.6	499.6

[a]Thun et al. (1997a).
[b]Adjusted rates (in parentheses) were used to calculate the rates in Table E-1. See text for adjustment method.

To implement this approach an estimate is needed for p_{SM}, the proportion of smokers in the U.S. population. Based on the NHIS administered in 2000 to a nationally representative sample of the U.S. non-institutionalized population over 18 years of age, the proportion of current smokers was 0.257 among men and 0.210 among women. Smoking prevalence was fairly age-independent, except among persons greater than 65 years of age. Among men the proportions of current smokers was 0.285, 0.297, 0.264, and 0.102 among men aged 18–24, 25–44, 45–64 and ≥65, respectively. The corresponding proportions for women were 0.251, 0.245, 0.216, and 0.093 (Trosclair et al. 2002). The oldest category likely includes a sizable percentage of former smokers whose mortality rates are influenced by their former smoking habits. Because of this and related problems, it was decided not to age-adjust smoking rates, but simply to apply the overall rates from the NHIS survey. Consequently, the proportion of smokers was assume to be p_{SM}=0.257 in men and p_{SM}=0.210 in women.

Smoking-specific mortality rates were not available from CPS-II below the age of 35. Additionally, in both males and females the CPS-II lung cancer rates in the lowest age categories were based on fewer than 10 deaths, and consequently quite uncertain. In these age categories, the lung cancer rates were adjusted using a cubic function of (age less the oldest age at which the 2000 U.S. rate was zero), keeping the total expected number of lung cancer deaths in these categories equal to the observed number. The resulting adjusted rates are shown in parentheses in Table E-2. Equation E-10 was applied to these adjusted rates.

Turning now to all-cause mortality, for males between the ages of 35 and 60, the CPS-II all-cause mortality rates in smokers were approximately three times the rates in non-smokers (RR≈3). Consequently, to estimate smoking-specific rates below the age of 35, equation E-10 was applied using RR=3 between the ages of 20 and 35 and RR=1 for earlier ages. For women, since the all-cause mortality rates in smokers and non-smokers differed by less than 10% between the ages of 35 and 45, the rates in smokers and non-smokers were assumed to be equal below the age of 35. The resulting smoking-specific rates are shown in Table E-1. The difference in estimated rates between smokers and non-smokers is not necessarily solely due to smoking; other differences in lifestyle between smoker and non-smokers likely contributed, particularly among males.

REFERENCES

Center for Disease Control National Center for Health Statistics (CDC). GMWK210. Death Rates for 113 Selected Causes, by 5-year Age Groups, Race, and Sex: United States, 1999-2000. http://www.cdc.gov/nchs/datawh/statab/unpubd/mortabs/gmwk210_10.htm. 2003.

Thun MJ. Personal Communication to Dr. Kenny Crump. 2003.

Thun MJ; Day-Lally C; Myers DG; Calle EE; Flanders WD; Zhu BP; Namboodiri MM; Heath CW. Trends in Tobacco Smoking and Mortality from Cigarette Use in Cancer Prevention Studies, I (1959 through 1965) and II (1982 through 1988). In *Changes in Cigarette-Related Disease Risks and Their Implication for Prevention and Control.* Burns D; Garfinkel L; Samet J; (eds.). Smoking and Tobacco Control Monograph, No. 8, National Institutes of Health, National Cancer Institute. Government Printing Office. Bethesda, MD. 1997a.

Thun MJ; Peto R; Lopez AD; Monaco JH; Henley SJ; Heath CW; Doll R. Alcohol Consumption and Mortality among Middle-aged and Elderly U.D. Adults. *The New England Journal of Medicine*. 337(24):1705-1714. 1997b.

Trosclair A; Husten C; Pederson L; Dhillon I. Cigarette Smoking among Adults – United States, 2000. *Morbidity and Mortality Weekly Report. Surveillance Summaries*. 51(29):642-645. 2002.